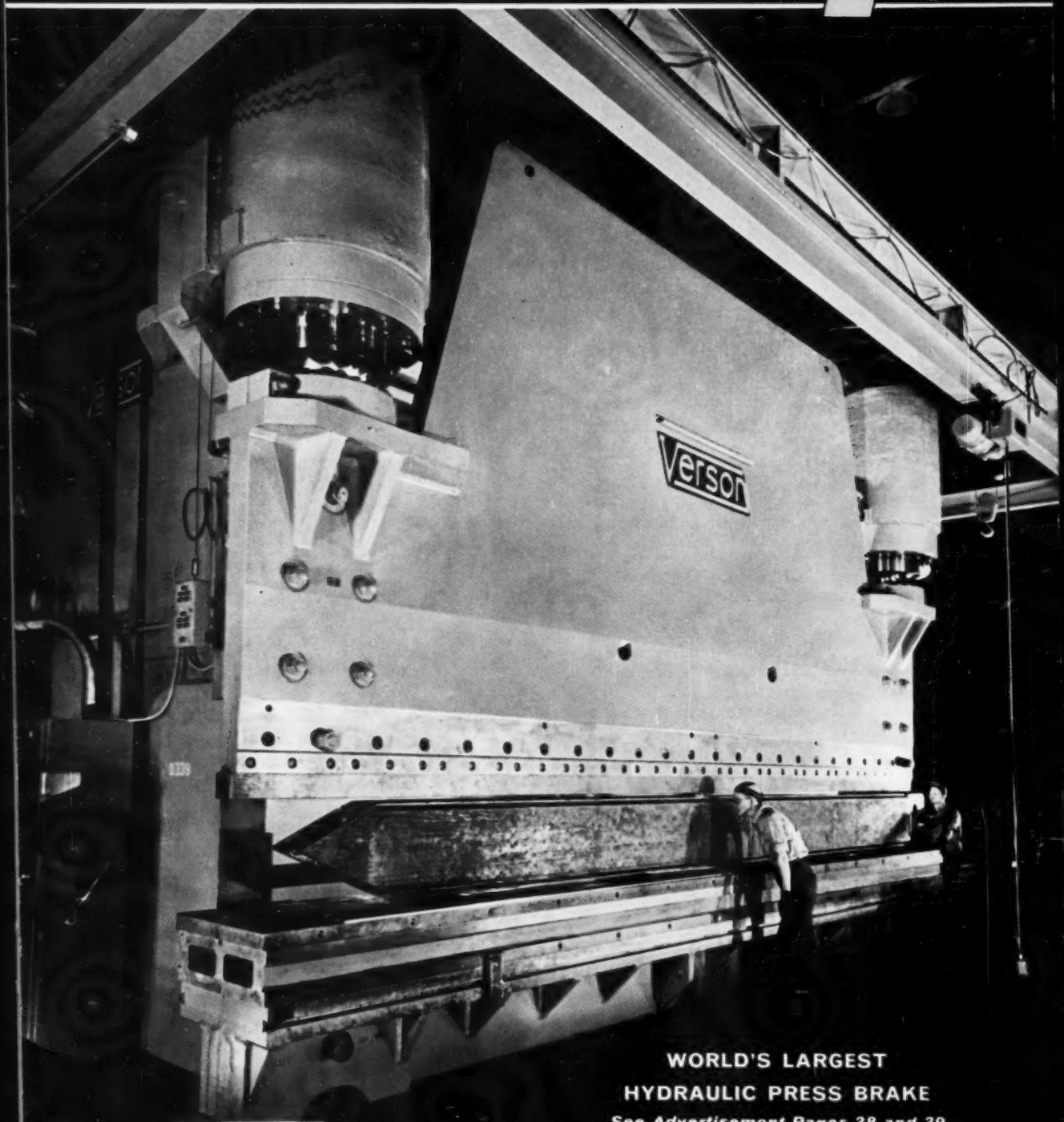
ENGINEERING AND PRODUCTION IN METALWORKING AUGUST, 1961

Machinery



WORLD'S LARGEST
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EFFECTIVE COOLING...

How to Avoid Barrel-Shape Bores

by Dr. Robert Hahn
Chief Research Engineer
The Heald Machine Company

One of the oldest problems in high-precision internal plunge grinding is that of the unwanted barrel-shaped hole. For some time the cause of this seemingly unavoidable defect was not well understood. How could a perfectly straight wheel, perfectly aligned with the bore, plunge grind a barrel-shape hole?

Recent investigations in this area, as part of our continuing quality improvement program, have isolated the cause and pointed the way to some fairly simple solutions to the problem.

The culprit is *heat*. At the area of contact between work and wheel, the generated heat is more quickly dissipated at the ends of the bore than at the center. This temperature relationship is shown in Fig. 1, with surface temperatures reaching maximum value at the center of the bore. Maximum temperature means maximum thermal expansion—expansion that forces more metal into the wheel at the center of the bore than at the ends. With this unequal stock removal, the bore assumes a barrel shape on cooling. These relationships hold true for plunge grinding, and also, but to a lesser extent, for some cases in traverse grinding where limiting factors require a short stroke.

To reduce the barrel shape, it is necessary to level out the temperature curve—by reducing the amount of heat generated and by providing more effective cooling.

The contact area between wheel and work can be considered as a moving heat source that travels around the bore at a rate equal to the workhead speed. The faster this heat source travels, the less the heat will penetrate into the metal. Hence higher work speeds will reduce local heating. And since the heat generated is a function of contact pressure and surface feet per minute, lighter feeds and slower wheel speeds in such cases also help to reduce the thermal distortion.

Water-base coolants, copiously applied, have also proved an effective remedy. As shown in Fig. 2, the coolant flow should maintain a full "reservoir" at the bottom of the bore, as well as between the wheel and work. The coolant flow at the bottom of the bore quenches the metal immediately after the ground surface passes the wheel and assures maximum cooling effect before this point again contacts the wheel.

In practically all cases, a judicious combination of these factors—faster work speeds, slower wheel speed, lighter feeding pressure and improved cooling—will reduce the barrel-shape of a bore to negligible values. This study is typical of the continuing research being conducted at Heald to help refine the art of modern metalworking. Your nearest Heald representative will be glad to help you solve your particular grinding or boring problems.

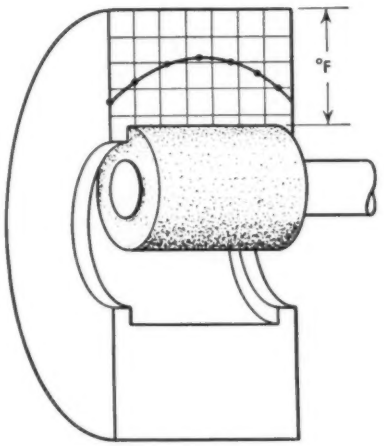

FIG. 1. Section through plunge-ground bore, showing unequal temperature rise in the metal which results in barrel-shape bore on cooling.

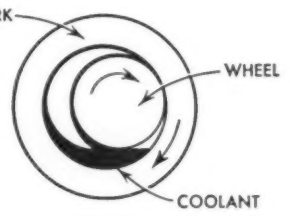

FIG. 2. End view of wheel and work, showing coolant flow for most effective dissipation of heat.

It PAYS to come to Heald

THE HEALD MACHINE COMPANY
Subsidiary of The Cincinnati Milling Machine Co.
WORCESTER 6, MASSACHUSETTS

AUGUST 1961

VOL. 67 No. 12

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RAYMOND H. SPIOTTA

Associate Editors:
FREEMAN C. DUSTON
HAROLD W. BREDIN
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Materials Editor: PAUL B. SCHUBERT

Published monthly by THE INDUSTRIAL PRESS. ROBERT B. LUCHARS, *President;* EDGAR A. BECKER, *Vice-President and Treasurer.* Editorial, Advertising and Circulation Offices: 93 Worth St., New York 13, N. Y. Telephone, CAnal 6-8120.

Business Manager
ARNOLD F. CARUSO

Advertising Representatives
WALTER E. ROBINSON

W. R. WASHINGTON
93 Worth St., New York 13, N. Y.

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Subscription rates: United States and Canada, one year, $10; foreign countries, one year, $15; two years, $28. Single copies, $1.00; foreign, $1.50. Changes in address must be received by the first of the month to be effective for the next issue. Send old as well as new address. Copyright 1961 by THE INDUSTRIAL PRESS.

Accepted as controlled circulation publication at Bristol, Conn.

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MACHINERY
National House, West St., Brighton 1, England
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Clifton House, 83-117 Euston Road
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15, Rue Bleue, Paris-IXe, France

Machinery

THE MONTHLY MAGAZINE OF ENGINEERING AND PRODUCTION IN THE MANUFACTURE OF METAL PRODUCTS

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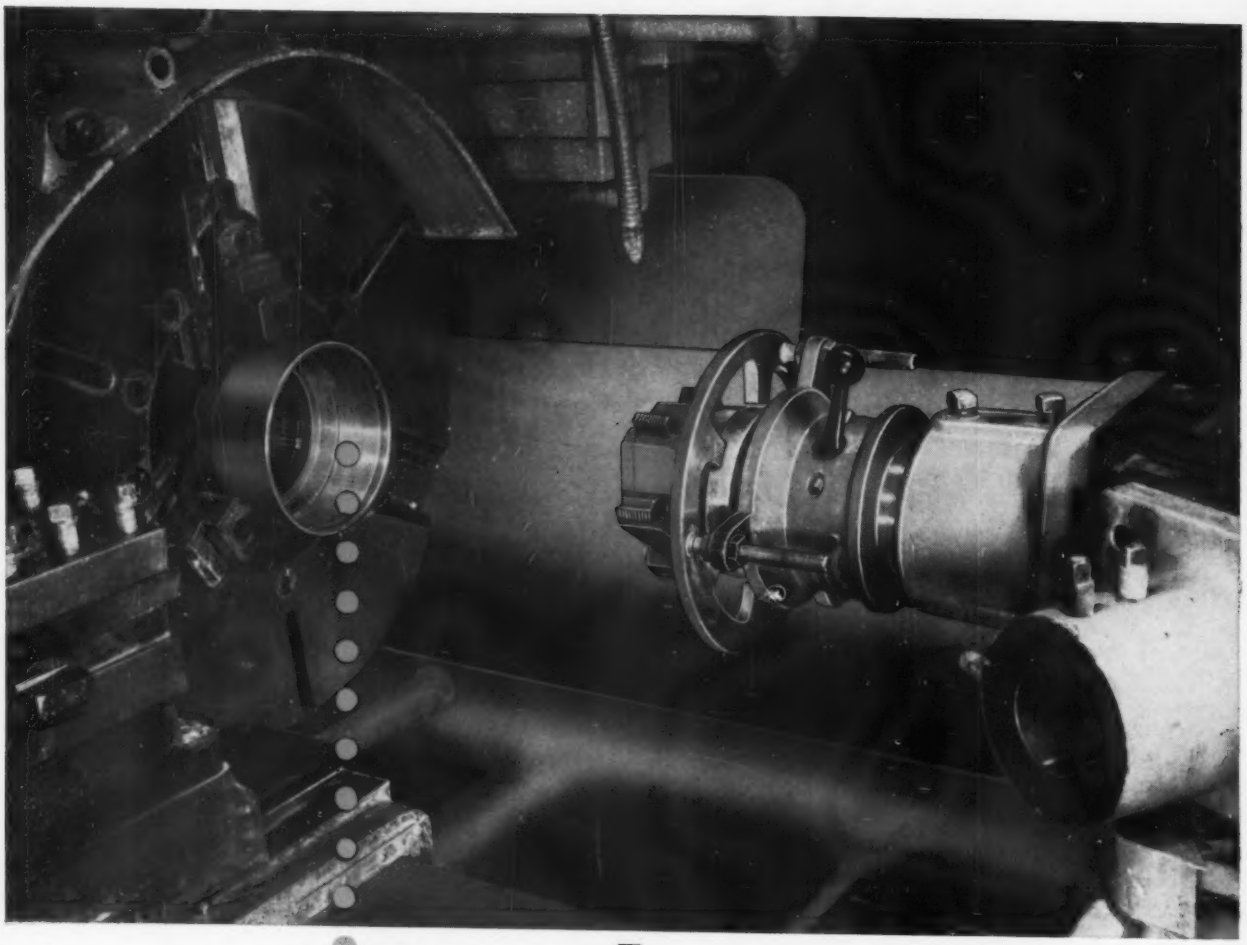
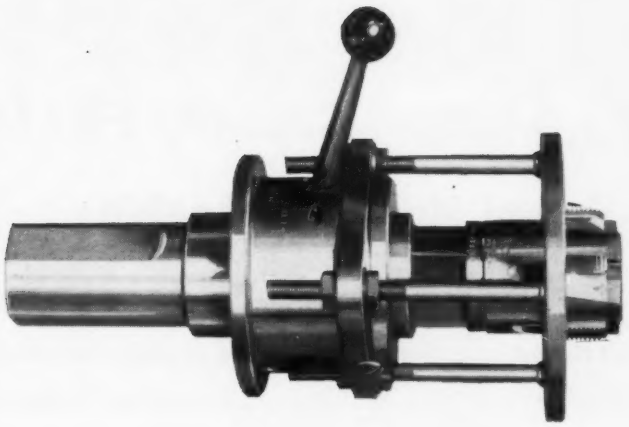


tapping 7-5/8" threads in tough steel



Rugged construction, allowing heavy metal removal in one pass, is one of the reasons a LANDIS Collapsible Tap is used to thread cylinder retainer caps for heavy duty hydraulic cylinders at the Cleveland Hydraulic Co., Bedford Heights, Ohio.

A LANDIS 6ALT Tap with a 7″ head is mounted on a turret lathe for threading 40-50 carbon cast steel normalized from 1600° to 1750°. 7⅝″ 8-pitch UN threads are tapped $2\frac{3}{16}$″ long to Class 2 fit.

Another outstanding feature of the LANDIS ALT Collapsible Tap is the detachable head, permitting the use of tap heads of various sizes and capacities on the same tap body. For example, on the 6ALT illustrated, five heads will allow a threading range 6½″ to 13¼″. In addition, each tap head has a relatively wide threading range — the 7″ head shown here threads all diameters from 6½″ to 8″. Thus, as a result of the minimum equipment required for such wide range coverage, low initial cost and continuing economy of tooling are assured.

LANDIS ALT Taps may also be used to produce taper threads, with chasers cutting across their entire width if required. For more complete information on the various sizes of ALT Taps for threading all diameters from 1¼″ to 13¼″, write for Bulletin G-94.

499C

the world's largest manufacturer of threading equipment

LANDIS *Machine* COMPANY

WAYNESBORO • PENNSYLVANIA

CUTTING · GRINDING
ROLLING · TAPPING

For more data, circle this page number on Readers' Service Card.

NOW...A Larger Capacity FELLOWS-PFAUTER High-Speed Hobbing Machine...The P 630

You get all the advanced-design features of the production-proved P 400 Fellows-Pfauter hobbing machine — plus extra work capacity — with the new Model P 630. Takes work up to a diameter of 25″. Maximum face width at 25″ diameter is 16¼″. Maximum diametral pitch in steel is 3. It's fast, easy-to-handle . . . and it's built for high production.

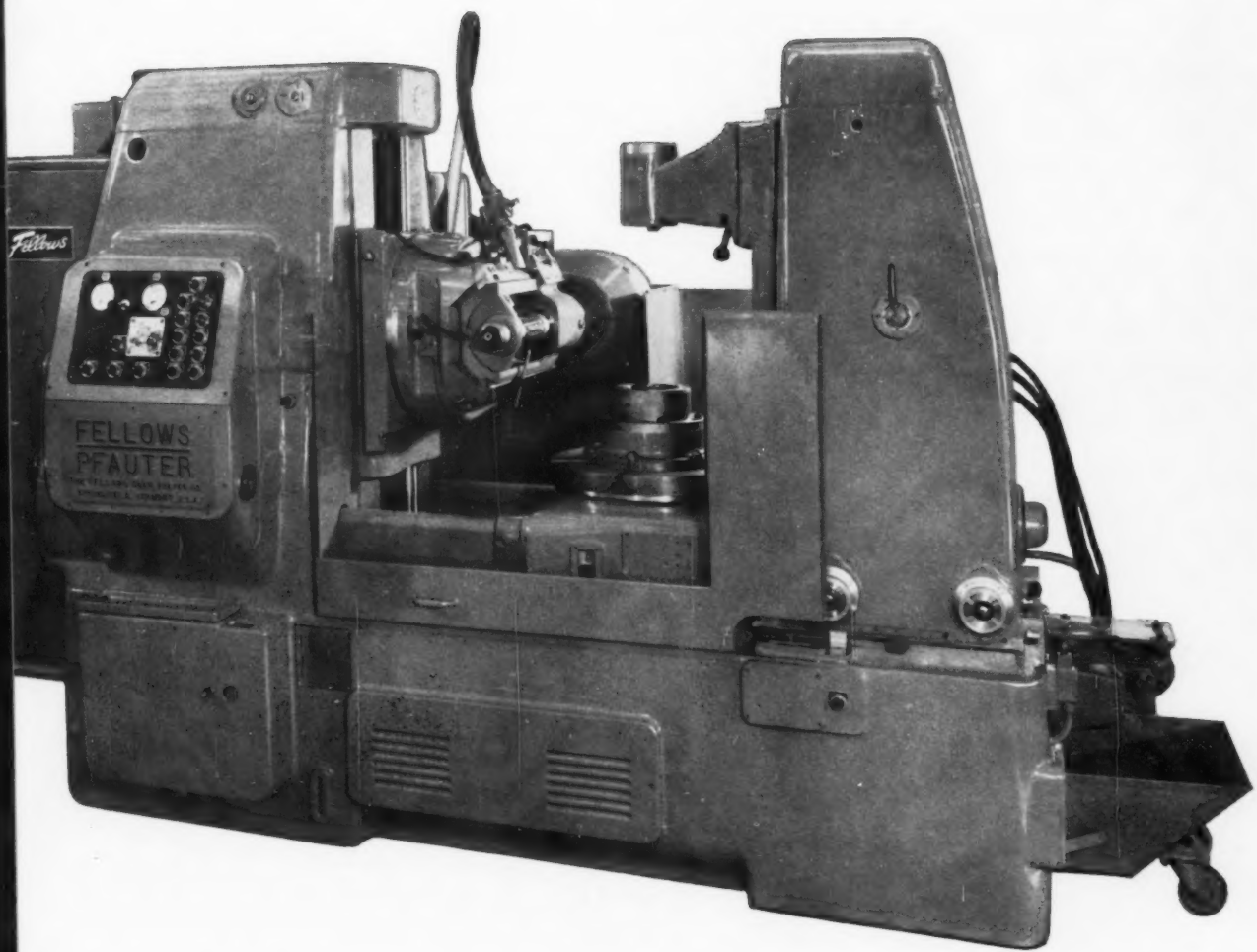
For example: Work area is readily accessible for setup and loading. Table retracts automatically from hob to facilitate work changes. Hob shifting is controlled by pushbutton. And built-in hydraulics assure smooth operation of tailstock and fixtures.

Solid construction features include: rugged hob head and double wall construction column and bed, with heavy V-ways. Table is as large as maximum workpiece diameter, and index worm gear nearly as large as work table. Work column is of massive design.

Reduce your production costs with this new Fellows-Pfauter. Get complete details now.

NEW . . . Dictionary of Change-Gear Combinations

Eliminate tedious calculations and trial-and-error methods for finding change gear combinations. Now, simply look them up like words in a dictionary in "Fellows-Pfauter Change Gear Tables" by F. Becher and A. Koerner. This English edition contains combinations for more than 26,000 ratios carried to six decimal places from .100,000 to 1.000,000, with the greatest step approximately .00005. Change gears in the range of 18 to 80 teeth are mainly used. Examples of applications are given. Only $8.00. Get a copy now. Send your order to THE FELLOWS GEAR SHAPER COMPANY, 78 River Street, Springfield, Vermont, U. S. A.



THE FELLOWS GEAR SHAPER COMPANY
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THE PRECISION LINE

Fellows

Gear Production Equipment

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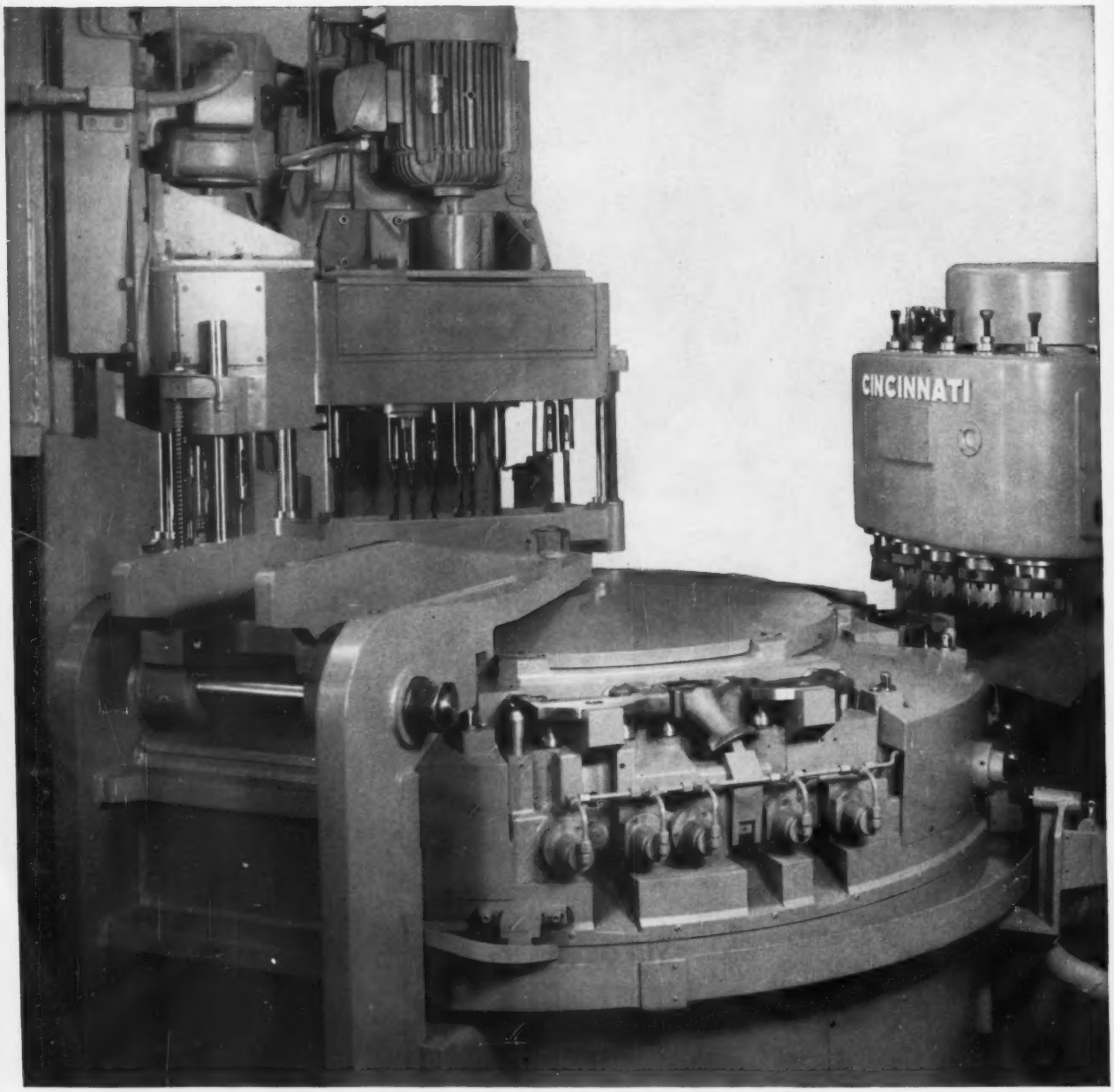
CINCINNATI

Rotary Index Machining..



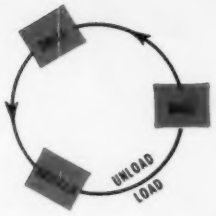
Milling, drilling and broaching operations are completed on exhaust manifolds at a production rate of 105 parts per 48 minute hour. Broaching is free, performed during the rapid index segment of the cycle.

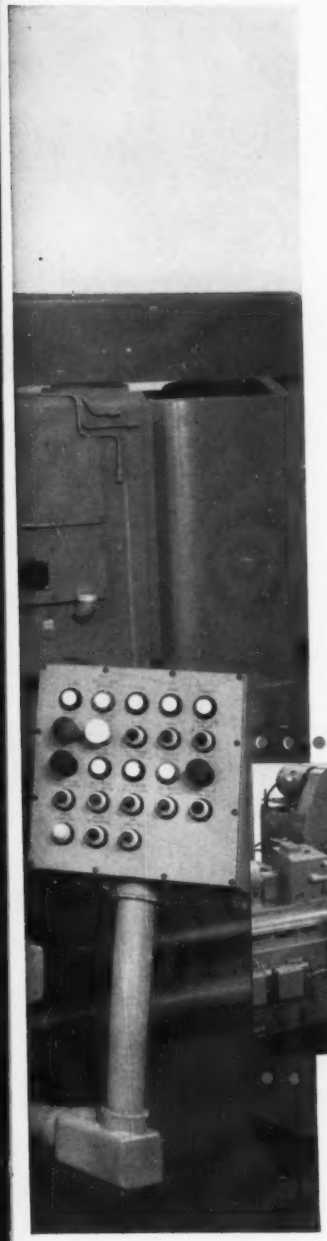
DESIGNERS AND BUILDERS OF SPECIAL MACHINES • HORIZONTAL BROACHING MACHINES

THE CINCINNATI MILLING MACHINE CO., CINCINNATI 9, OHIO

..converts production lines *into*

Space-saving circles

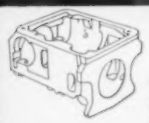




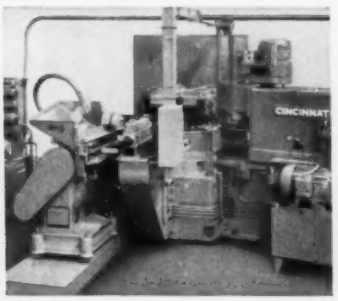
Take a conventional straight production line, bend it into a circle, and you have the basic idea of CINCINNATI Rotary Index Machines. These unique automatic machines take the work in a circular path which becomes the shortest distance traveled to achieve low-cost production.

Cincinnati's Special Machine Division has built many highly successful machines of this type . . . some for milling, others for milling and drilling, while still others include a free broaching operation. Four examples are illustrated here. All include standard time-tested mechanisms which are used in other Cincinnati machines. And all incorporate the "building block" approach to construction, which reduces lead time . . . allows replacement of modules or units if required by design changes.

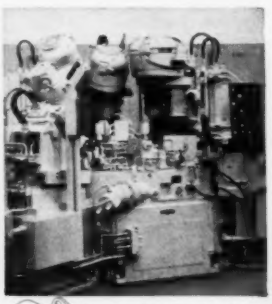
Cincinnati is staffed and equipped to build all types of numerically controlled equipment and automatic machines or production lines having any desired degree of automation. May we help you?

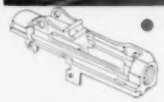


Milling, drilling and reaming operations are performed on transmission cases at the rate of 85 cases per 48 minute hour.



Automatic loading and unloading keep this CINCINNATI busily performing three operations on 600 cotton picker spindles per hour.





Thirty separate milling operations on complex gun receivers are performed by six CINCINNATI Station Type Rotary Machines.

CINCINNATI

COMPLETELY AUTOMATED PRODUCTION LINES

CINCINNATI®
SPECIAL MACHINE DIVISION

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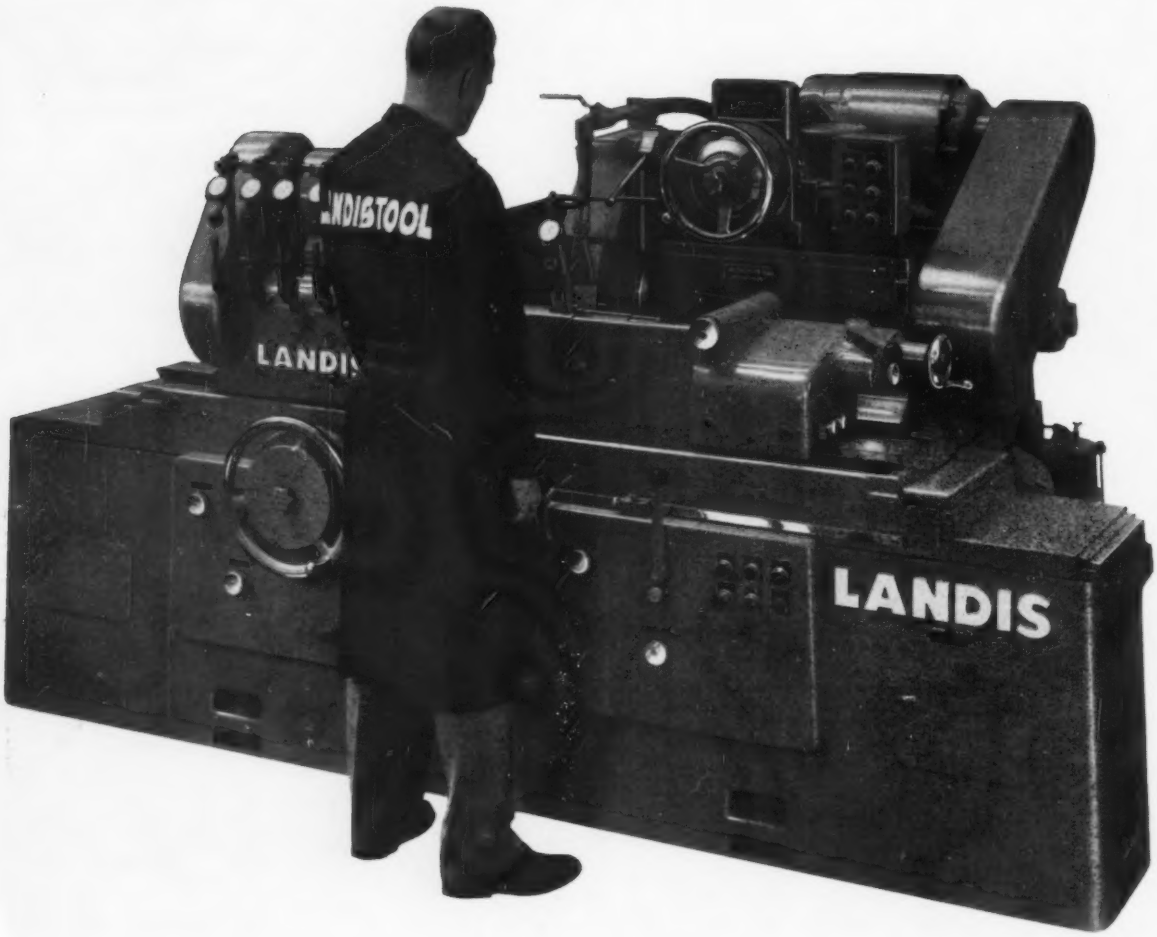
6 **NEW** features of Landis plain grinders mean closer tolerances for size, roundness, uniformity



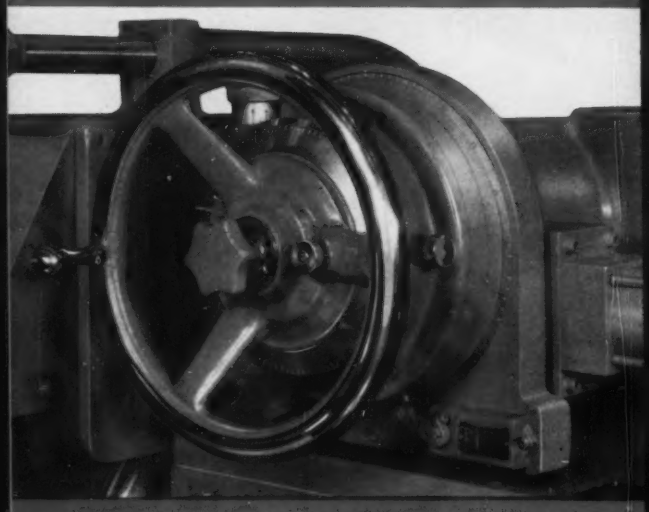
10" x 36" Type R Plain with optional Size Finder and Microfeed

LANDIS

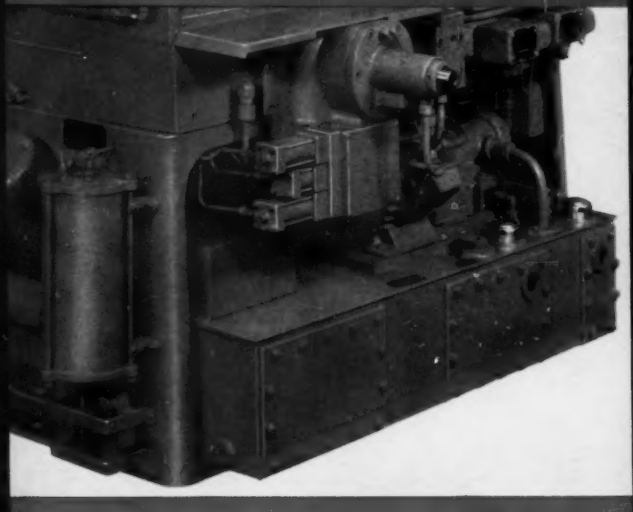
LANDIS TOOL COMPANY, WAYNESBORO, PA.

New shake free footstock with preloaded ball spindle eliminates shake. No need for adjustments because of wear.

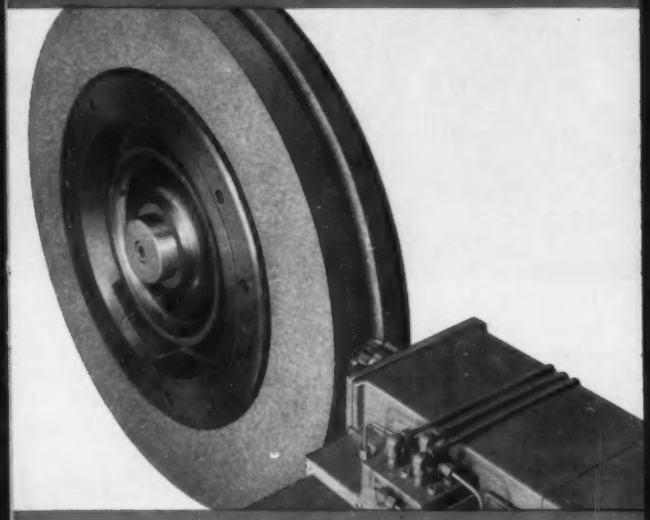
MICROFEED© . . . a fine increment feed to final size that consistently grinds to your closest tolerances. Extra equipment.



New eye level wheel feed with turning handwheel shows both rate and amount of feed on semiautomatic machines.

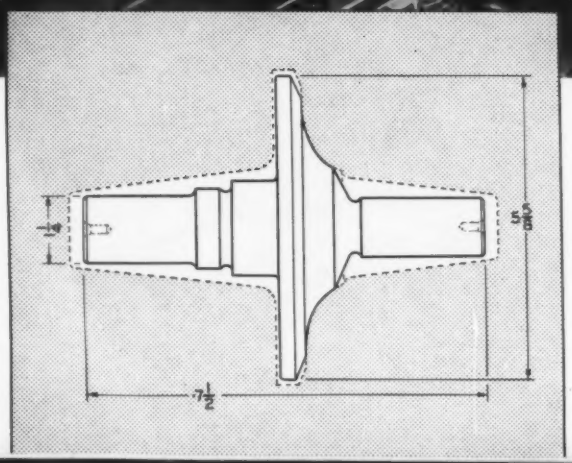


New isolated oil reservoir maintains machine alignment through better temperature control.



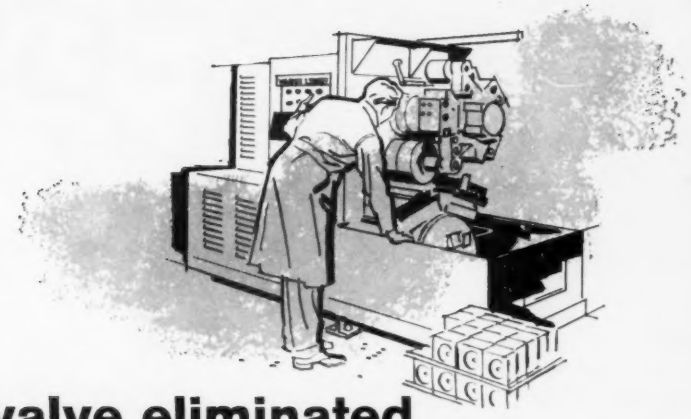
TRUFORM Wheel Dresser...preloaded ball slide design eliminates shake. Assures exact duplication of the profile on the wheel. Extra equipment.

Size Finder . . . a direct reading indicator used with Microfeed to reduce setup and grinding time in the grinding of multiple diameter shafts. Extra equipment.



Valve bumpers like this are produced from 8260 forgings in lots of 250 pieces. Eight previous operations included milling, center-drilling, turning, threading, and grinding. Now these parts are produced on a Warner & Swasey 2AC Chucking Automatic in two operations plus one grinding setup.

AT GARDNER-DENVER CO.
Quincy, Illinois



5 operations on valve eliminated by accuracy and tooling versatility of 2AC

In addition to direct savings at the machine, the 2AC Chucker cuts paper work, part handling, transport time, scheduling problems, and other fringe costs throughout the shop.

The standard 2AC "late cross slide" activates an angular cutter slide which is equipped with a hydro-check unit. This combination produces a fine finish with no cutter withdrawal marks.

The cost reducing influence of this Warner & Swasey 2AC Chucking Automatic has been felt in many departments other than Gardner-Denver's machine shop. For example, by eliminating five operations from the valve bumper, illustrated at the left, here is where they were able to find additional cost savings:

1. **Reduced** methods department paper work and man-hours.
2. **Saved** 5 days on machine-to-machine scheduling and transportation.
3. **Reduced** direct part handling and damage from moving.
4. **Eliminated** rust preventive spraying between operations when lack of open machine time prevented prompt scheduling to the next operation.
5. **Eliminated** one finish grinding operation because of the 2AC's ability to hold size and finish.

Eight operations were replaced by two operations on the 2AC plus a finish grinding. Total setup time of 11¼ hours was cut to 4¾ hours plus time for the remaining grinding setup.

Discover what a 2AC can do in your shop. Contact the Warner & Swasey Field Engineer in your area.

YOU CAN TURN IT BETTER, FASTER,
FOR LESS...WITH A WARNER & SWASEY

WARNER & SWASEY

For more data, circle this page number on Readers' Service Card.

NEW ARMSTRONG CATALOG

Quality Tools for Industry

New ARMSTRONG General Catalog #700, showing the complete ARMSTRONG Line, has been released. This catalog lists approximately *330 tools that have not been included in previous* ARMSTRONG Catalogs.

Additions have been made in the following categories:

Tool Holders
Set-Up-and-Hold-Down Tools
Tool Bits
Wrenches
Ratchet Wrenches and Sockets
Miscellaneous Hand Tools
Pipe Tools

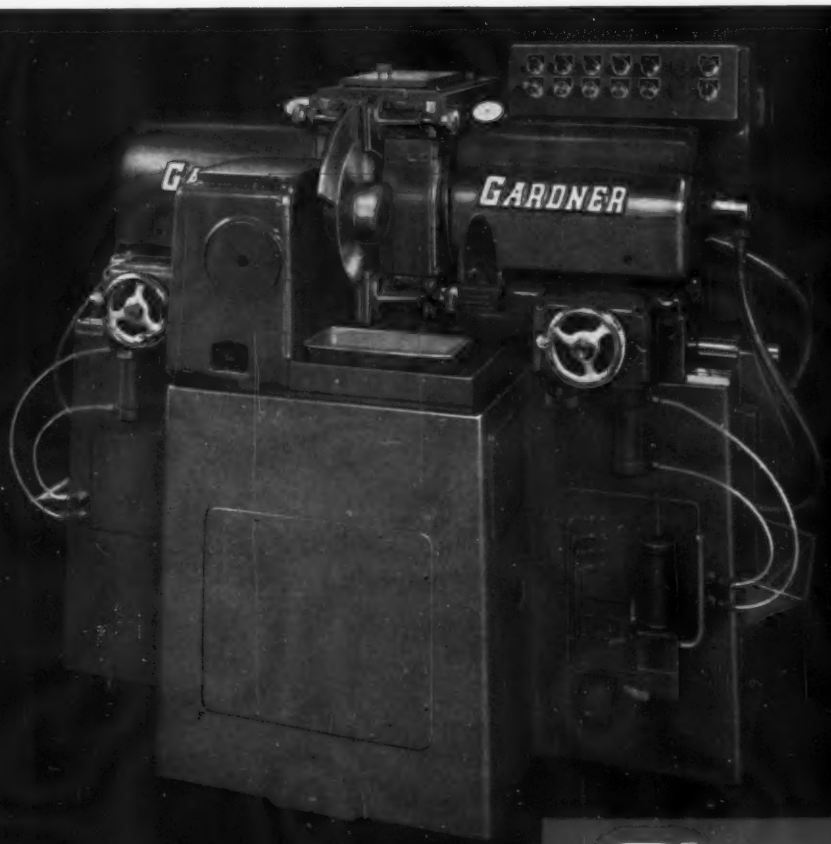
Get your free ARMSTRONG Catalog No. 700 showing these important additions, as well as the thousands of other tools included in the ARMSTRONG Line. The catalog is a necessity for anyone who uses or buys hand tools or shop tools. Write direct, or phone your local ARMSTRONG Distributor (who has a supply of new catalogs on hand). If you do not know which distributor in your area carries the ARMSTRONG Line, we will be glad to supply this information upon request.

ARMSTRONG BROS. TOOL CO. 5213 W. ARMSTRONG AVE. CHICAGO 46, ILLINOIS

NEW 2H10

disc grinds parts to millionths

compact Gardner Double Disc Grinder finishes small precision parts at high output



This is the smallest machine in the Gardner 2H series. It is equipped with either 12" or 15" discs and 3, 5, 7½ or 10 hp motors.

grinds two surfaces parallel in one operation

disc grinds parts like these

counter pinions

contact lens blanks

ceramic insulators

magnet cores

small bearing roll

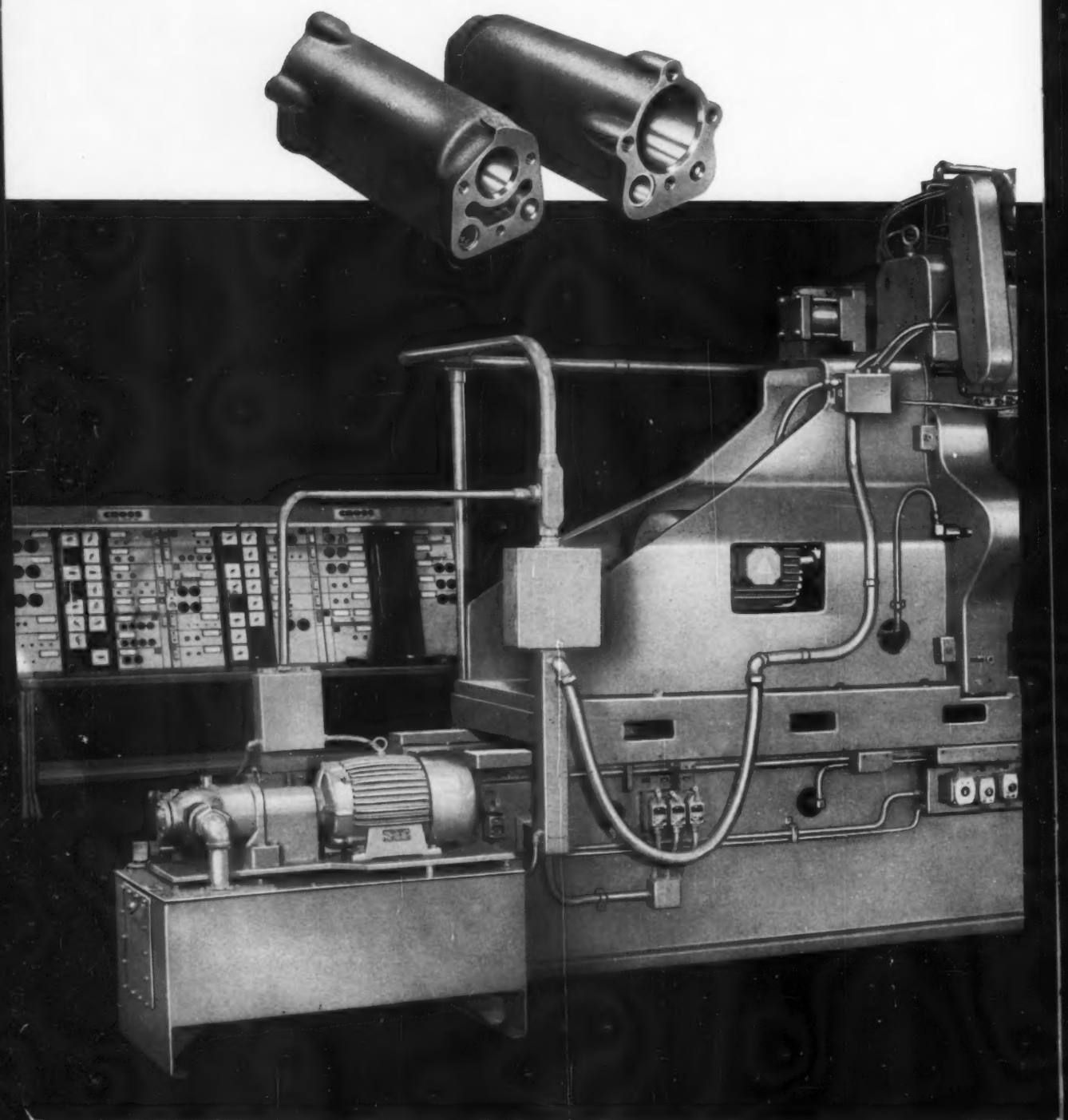
miniature bearing races

GARDNER

GARDNER MACHINE COMPANY, BELOIT, WISCONSIN
a subsidiary of Landis Tool Company

New Cross Trunnion Machine with Greater Flexibility

Processes remote accessory cylinders of different designs and different materials



Another Automation First by Cross

Recent developments by Cross have resulted in trunnion machines that perform a variety of operations on families of parts with improved accuracy and at a higher rate of production than previous equipment.

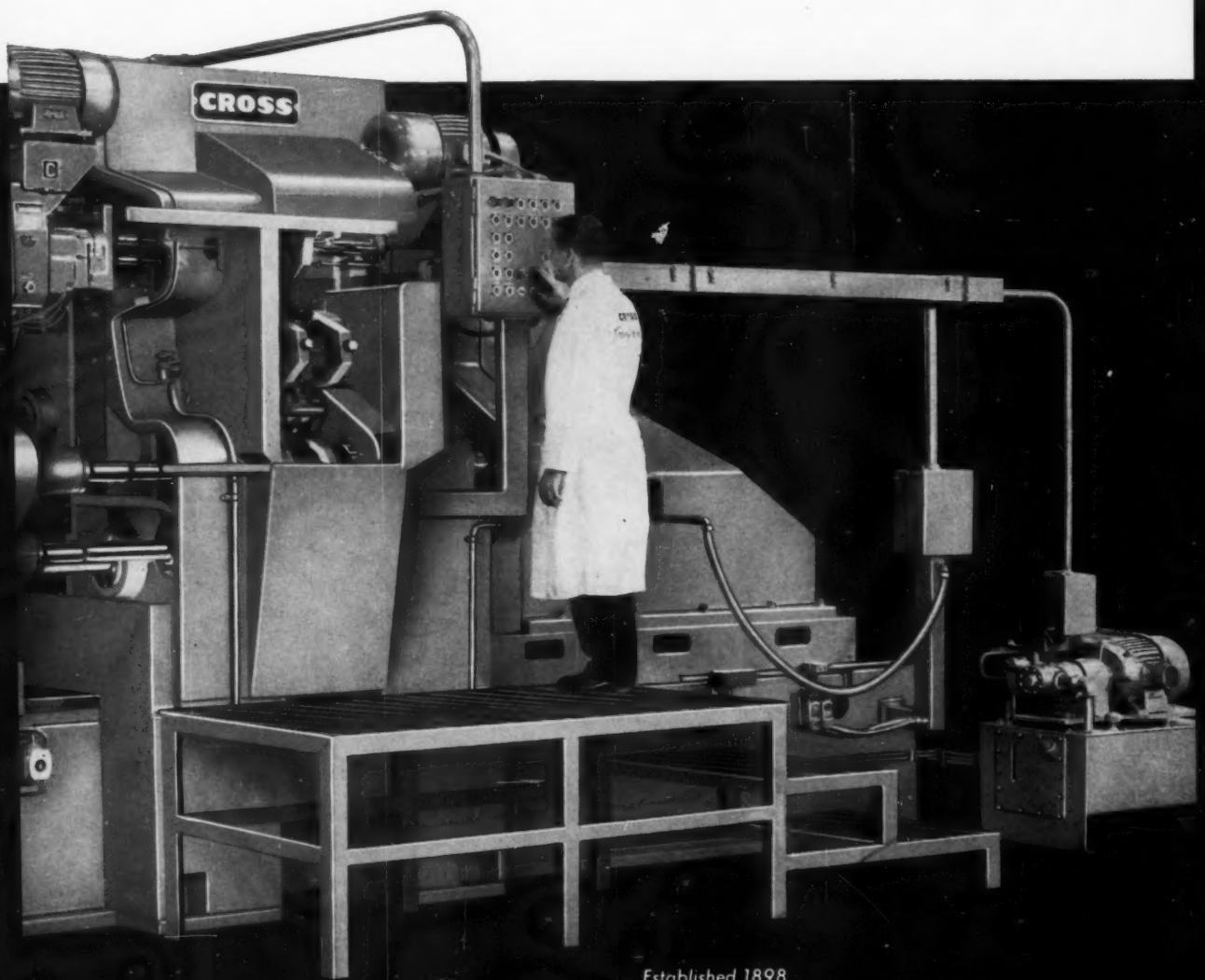
A typical application of the new design concept is the processing of remote accessory cylinders which vary in both size and material. Different lengths are handled by changing a few tools, replacing some fixture details and adjusting the feed strokes. Both nodular and grey iron castings are processed by changing the speeds and feeds.

Similar operations such as rough, semi-finish and finish boring; drilling; counterboring and chamfering are completed by spindles in the two main heads. Dissimilar work such as tapping, facing and grooving are done by four auxiliary heads.

Extremely close tolerances are maintained through single clamping of the part, precision indexing of the trunnion and boring bars which are accurately guided in the trunnion supports.

Future part design changes can be accommodated easily because of the extreme flexibility of the machine.

A Cross Sales Engineer will be glad to tell you more about this new trunnion machine design.



Established 1898

THE **CROSS** CO.

First in Automation

PARK GROVE STATION • DETROIT 5, MICHIGAN

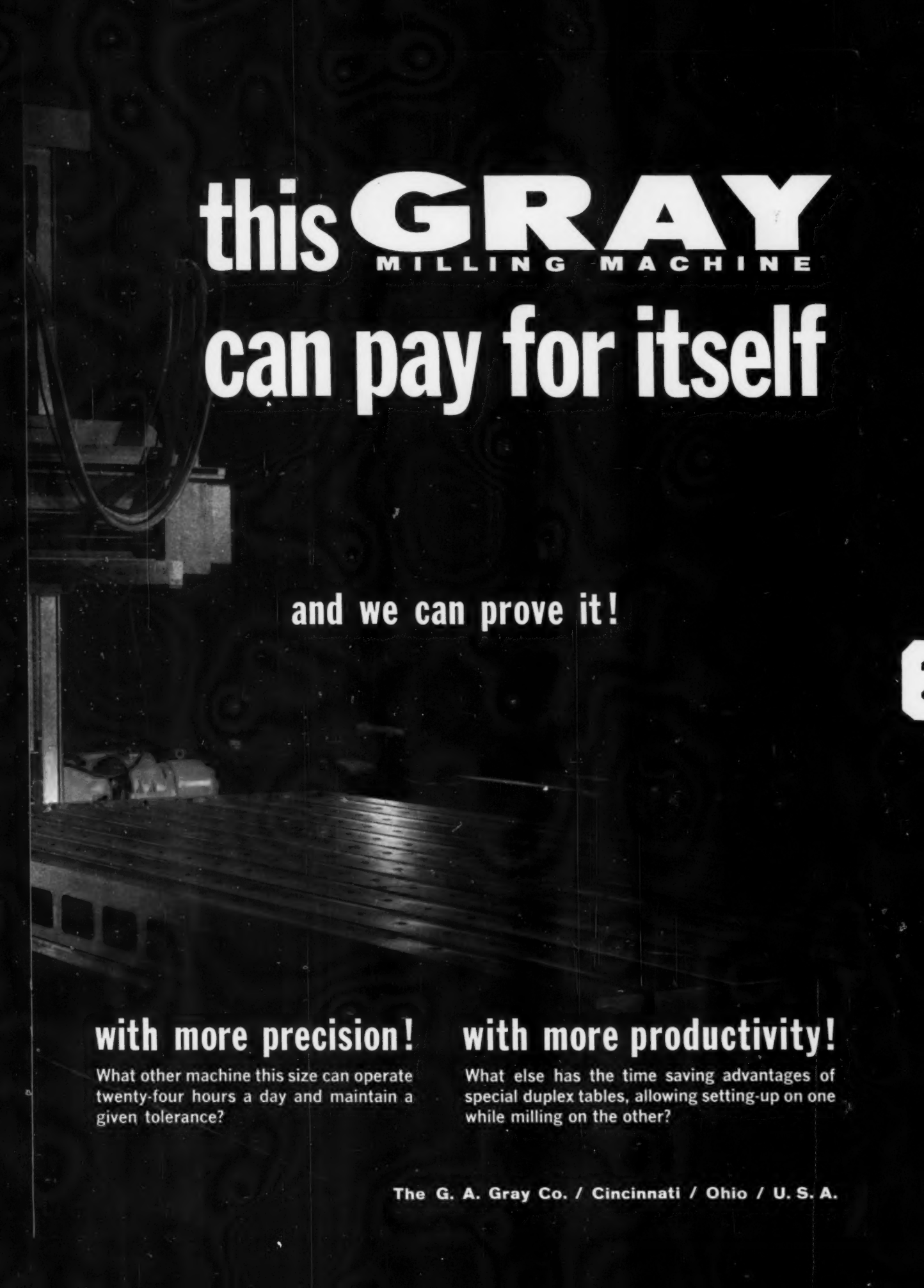
with more cutting power!

What other milling machine—planer type, has the flexibility of four 75 H.P. units heads, pouring a total of 300 H.P. into the job?

with more control!

What else has a numerical control positioning system that gives visual indication of movement of railheads and table?

horizontal milling and boring machines / planers / milling machines—planer type


this GRAY
MILLING MACHINE
can pay for itself
and we can prove it!
with more precision!
What other machine this size can operate twenty-four hours a day and maintain a given tolerance?
with more productivity!
What else has the time saving advantages of special duplex tables, allowing setting-up on one while milling on the other?
The G. A. Gray Co. / Cincinnati / Ohio / U. S. A.

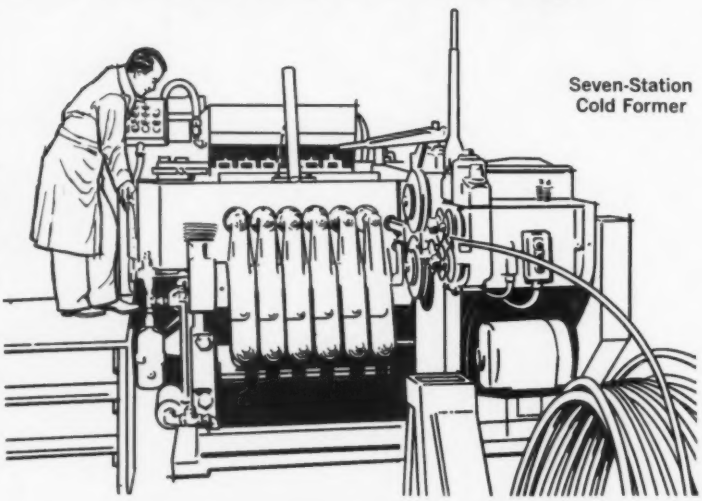
A New Look at Cold Forming!

The new National Seven-Station Cold Former now lets you make parts you had "shelved" as impractical. Six- and seven-station Cold Formers are routinely producing the formerly "impossible" jobs. Many are formed scrapless, most are practically finished, all are cold-formed automatically from coiled wire.

Production rates for these parts range from 45 to 115 *per minute!*

If you make odd-shaped parts, may we help you evaluate them for the potential that awaits you with these new Cold Formers? Come to Tiffin, witness our demonstrations and let's discuss your work.

No obligation.



Seven-Station Cold Former

FORGING MACHINES • MAXIPRESSES • REDUCEROLLS
BOLTMAKERS • NUT FORMERS • TAPPERS
COLD HEADERS • PARTS-MAKING MACHINES

NATIONAL MACHINERY CO.

TIFFIN, OHIO, U. S. A.

HARTFORD **DETROIT** **CHICAGO**

NOW—An Automatic Form and Groove Grinder . . . designed for tomorrow's production requirements!

WORKPIECES—Standard Ex-Cell-O Model 973 takes parts up to 24" long. Can be equipped for parts with 36" centers. Workhead adjustable for angular settings.

OPERATIONS—Precision-built for rough, semifinished or finished production grinding.

CONTOURS—Grinds straight, angular and radius grooves, and a variety of forms. Grinds multiple grooves when fitted with two or more wheels.

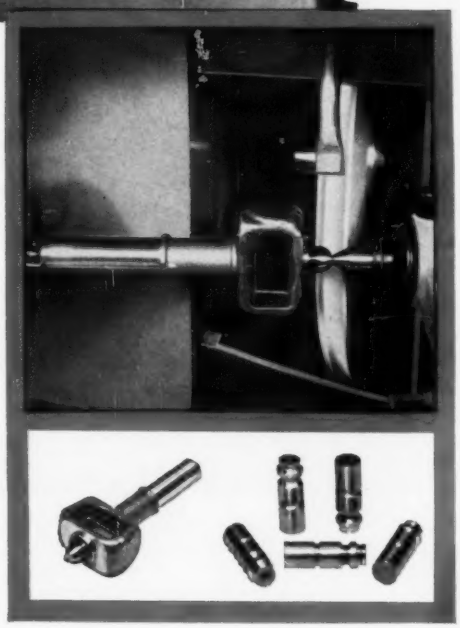
CYCLING—Fully automatic cycling, including opening and closing hood. Rapid wheel slide advance and return for maximum productivity.

SIZE CONTROL—Automatic wheel dressing after each cycle or any number of cycles. Automatic wheel size compensation after each dressing. (Handwheel graduated to .0002" for manual setting.)

DRESSERS—Designed for use with all standard Ex-Cell-O Diamond Dressers, or any special rotary diamond-set wheel dressers.

ACCESSORIES—Model 973 is a complete, versatile machine with extensive automatic features. However, it is designed to be easily equipped with automatic work loading and unloading devices, air operated chuck and tailstock and other accessories to meet your special requirements.

DATA AVAILABLE—Contact your local Ex-Cell-O Representative, or write direct for descriptive literature and engineering data.



61—25M

EX-CELL-O FOR PRECISION

PRECISION MACHINE TOOLS • GRINDING AND BORING SPINDLES • CUTTING TOOLS • RAILROAD PINS AND BUSHINGS • DRILL JIG BUSHINGS • JIG AND FIXTURE COMPONENTS • TORQUE ACTUATORS • CONTOUR PROJECTORS GAGES AND GAGING EQUIPMENT • GRANITE SURFACE PLATES • COMPUTER PRODUCTS • AIRCRAFT AND MISCELLANEOUS PRODUCTION PARTS • ATOMIC ENERGY EQUIPMENT • DAIRY AND OTHER PACKAGING EQUIPMENT

Machinery Division

EX-CELL-O CORPORATION
DETROIT 32, MICHIGAN

For more data, circle this page number on Readers' Service Card.

the **Monarch** 10" Model EE Lathe is made for sensitive, **super-accurate** turning of small **precision** parts

...and will do this consistently for the life of the lathe!

For super-precision and sensitivity in the toolroom, the Monarch 10" Model EE Precision Toolmaker's Lathe has long been the top choice of toolmakers everywhere. The features responsible for this also make the machine the ideal choice for precision manufacturing operations on such parts as small jet, missile, instrument, electronic and camera components.

General statements about the precision of a machine tool are easy to make. There is an irrefutable proof—the final inspection record. Following are some of the more critical standards as they apply to the 10" Model EE.

	Normal Standards	Monarch Standards
BED		
Level—longitudinal	.0005"	.0005"
Level—transverse	.0005"	.0001"
HEADSTOCK SPINDLE		
Face runout	.0003"	.0001"
Taper runout	.0003"	.0001"
Cam action	.0003"	.0001"
Taper hole runout	.0003"	.0001"
CROSS SLIDE ALIGNMENT		
Concave	.0005"	.0004"
HEADSTOCK ALIGNMENT		
Back of center at end of bar	.0003"	.0003"
High at end of bar	.0005"	.0002"

	Normal Standards	Monarch Standards
TAILSTOCK AND HEADSTOCK CENTERS ALIGNMENT		
High at tailstock	.002"	.0005"
LEADSCREW ALIGNMENT		
Vertical	.004"	.0015"
Horizontal	.004"	.0015"
LEADSCREW		
Cam action	.0003"	.0002"
Lead per foot	.001"	.001"
Lead per 4" section	.0004"	.0004"

Your search for the means to super-precision turn small parts is at an end. This is attested to by the thousands (that's right, thousands) of 10" Model EE's being used for such work. Ask for our sparkling new booklet No. 307. It tells all. THE MONARCH MACHINE TOOL COMPANY, SIDNEY, OHIO.

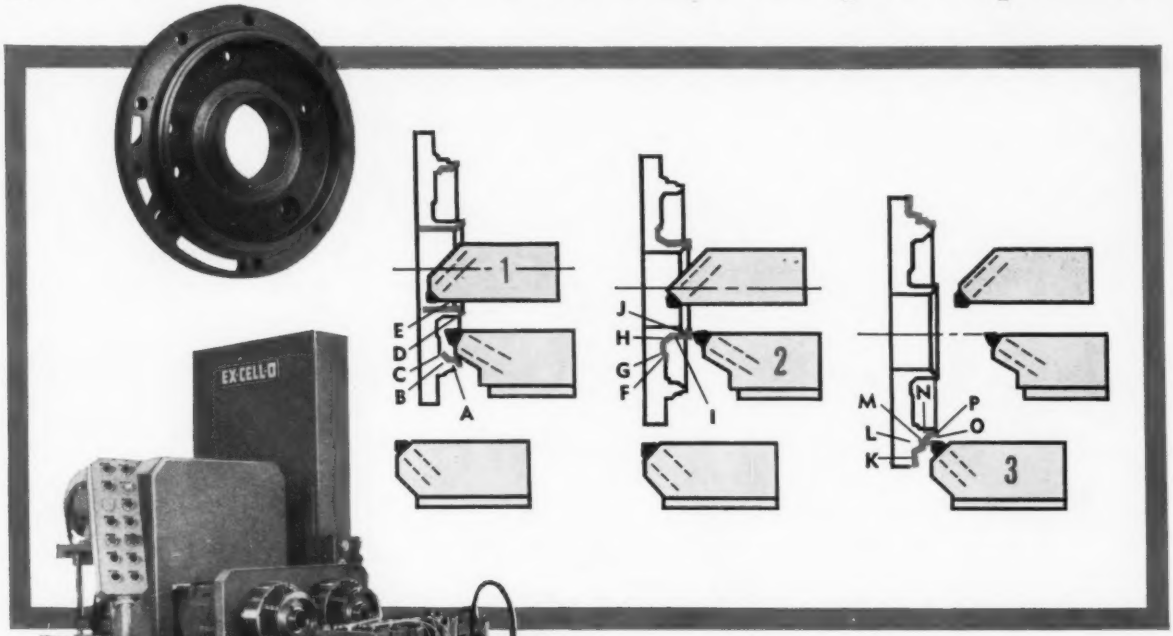
MAJOR 10" MODEL EE FEATURES. Drive to spindle through one set of multiple "V" belts at all speeds • Infinitely variable speed ratio of 100 to 1 through direct drive • Very low speeds secured through speed reduction elements of drive which extend ratio to 500 to 1 • Available with exclusive combination of electric leadscrew reverse and variable reverse speed control • Drive from spindle to gear box through endless belt • Drive motor power secured through advanced design of electronic conversion unit • Carriage held in secure alignment by ball bearing gibs • Bed and base made of special alloy cast iron • All four bed ways flame hardened and precision ground • Anti-friction bearings used throughout • Automatic lubrication • Every critical part made of heat-treated steel, accurately finished.

Monarch TURNING MACHINES

ASK ABOUT THE MONARCH DEFERRED PAYMENT AND TOOL LEASE PLANS

For more data, circle this page number on Readers' Service Card.

Ex-Cell-O Model 312 generates 21 surfaces per part!



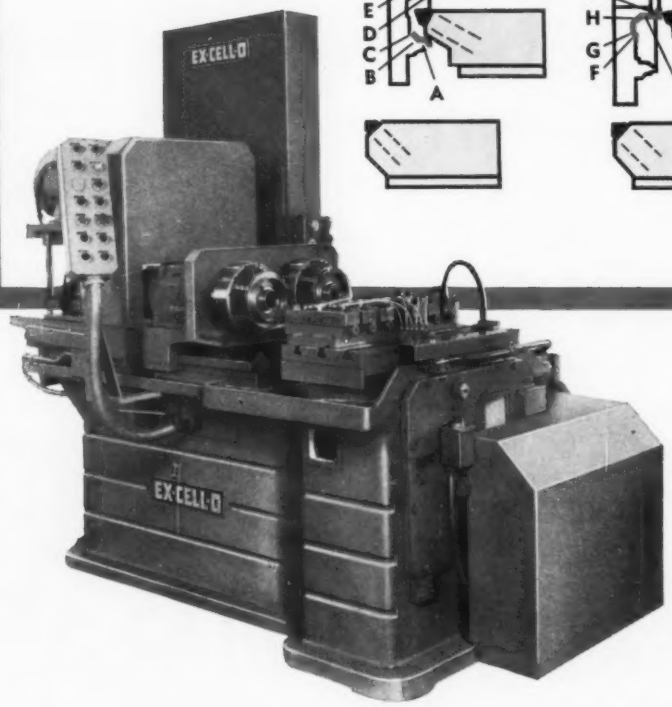


Diagram shows tools in quick-change magazines at the end of their strokes.

Tool No. 1 generates chamfer A, bores diameter B, generates radius C, traverses out, chamfers D and bores E.

Tool No. 2 generates surfaces F, G, H, I, and J with cam-controlled accuracy.

Tool No. 3 faces K, generates radius L, tapers M, turns N, chamfers O and generates radius P in cast-iron clutch assemblies.

Ex-Cell-O Cam-Operated Precision Boring Machines are designed especially for work requiring consistently precise boring, plunge-facing, grooving, chamfering and other O.D. and I.D. contours. Table and slide movements on hardened and ground ways are guaranteed by direct cam action—there are no levers, no complex linkages. For maximum accuracy, cams can be ground for you in our plant on numerically-controlled machines.

Two models, 308 and 312, rough, semifinish and finish a wide range of parts. Ask your Ex-Cell-O Representative for data, or write direct for details.

61-17M

EX-CELL-O FOR PRECISION

PRECISION MACHINE TOOLS • GRINDING AND BORING SPINDLES • CUTTING TOOLS • RAILROAD PINS AND BUSHINGS • DRILL JIG BUSHINGS • JIG AND FIXTURE COMPONENTS • TORQUE ACTUATORS • CONTOUR PROJECTORS GAGES AND GAGING EQUIPMENT • GRANITE SURFACE PLATES • COMPUTER PRODUCTS • AIRCRAFT AND MISCELLANEOUS PRODUCTION PARTS • ATOMIC ENERGY EQUIPMENT • DAIRY AND OTHER PACKAGING EQUIPMENT

Machinery Division

EX-CELL-O CORPORATION
DETROIT 32, MICHIGAN

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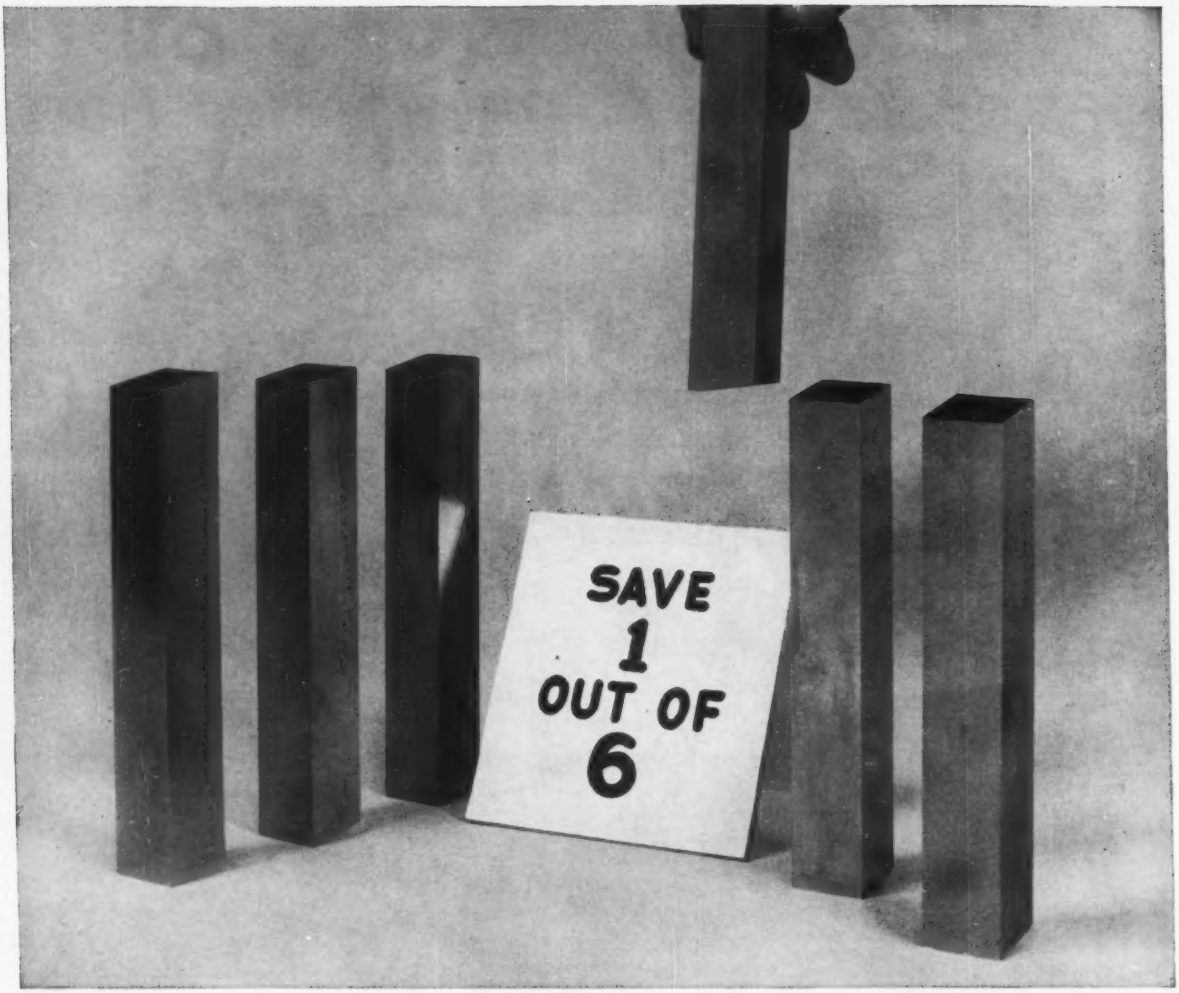

INCREASE TOOL LIFE AS MUCH AS 20%

Read how a "Cleartex Cure" ends the cutting oil dilution problem forever . . . increases tool life . . . slashes per-piece production costs as much as 40%.

Lube oil may be leaking into your cutting oil sumps this very minute. Surveys show it happens in 70% of all automatics. This dilution will reduce tool life, increase downtime, and result in premature discarding of cutting oil.

How a "Cleartex Cure" works. A "Cleartex Cure" checks these losses right away . . . prolongs tool life as much as 20%. Here's why: Cleartex Oil—heart of a "Cleartex Cure"—is used in both cutting and lubricating sumps. Cutting oil strength is always full—regardless of leakage. Over-all savings can slash per-piece production costs as much as 40%. Versatile Cleartex is a hydraulic fluid, too. *In fact, it's the tri-purpose cutting oil.*

How to take a "Cleartex Cure." Getting the full benefit of a "Cleartex Cure" is easy. An experienced Texaco engineer will survey your automatic set-up. He'll tell you which machines will benefit from Cleartex. Our illustrated booklet, "Cleartex in Automatic Screw Machines," spells out the benefits of a "Cleartex Cure" in detail.

To get the booklet, plus the survey, contact the nearest of the more than 2,300 plants distributing Texaco Products, or write Texaco Inc., 135 East 42nd Street, New York 17, N. Y., Dept. MA-110.

Tune In: Texaco Huntley-Brinkley Report, Mon. Through Fri.-NBC-TV

TEXACO

Throughout the United States
Canada • Latin America • West Africa

LECTRA-FORM
Increases Production 500%

Ex-Cell-O Model 244 machines recess 5 times faster, with far lower tool cost!

Ex-Cell-O LECTRA-FORM Machines remove metal through high-current, low-voltage electrical spark discharge. Producing an inverse image of low-cost shaped rod, tubing or sheetmetal tooling, LECTRA-FORM accurately drills, pierces, trepans, slots, cuts or sinks intricate cavities in carbides and other conductive materials difficult or costly to machine by other methods.

Contact your Ex-Cell-O Representative for details, or write for LECTRA-FORM Bulletin 436014.

Model 244 has an electro-hydraulic servo for automatic tool feed and gap control, removes metal without distortion due to tool pressure. Inset photo shows part before and after 8-minute LECTRA-FORM machining.

HERE'S HOW LECTRA-FORM COMPARES TO CONVENTIONAL MACHINING

WORKPIECE Nickel-alloy aircraft part*	LECTRA-FORM MACHINING	FORMER METHOD
Tooling	Low-cost brass rod	Small end-mill cutter
Tool cost	Negligible	High wear and breakage
Accuracy	Uniform wall thickness	Distorted wall contour
Machining time	**8 minutes**	**40 minutes**

*Depth of recess approx. .080", wall thickness approx. 1/32".

61-30M

EX-CELL-O FOR PRECISION

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Machinery Division

EX-CELL-O CORPORATION
DETROIT 32, MICHIGAN

For more data, circle this page number on Readers' Service Card.

Why Kearney & Trecker chose 8-channel punched tape input

The Kearney & Trecker Milwaukee-Matic is a remarkable tool even without numerical control. With NC, it's close to revolutionary. This automatic multi-machining center permits fast, economical small-lot manufacturing with minimum planning, far less lead time and dramatic reductions in tooling and inventory costs.

One major key to Milwaukee-Matic efficiency is the input. Kearney & Trecker picked 8-channel punched tape for reliability, durability, accuracy. And one thing more: ease of preparation on the Friden Flexowriter®. The Flexowriter has a standard typewriter keyboard. The operator (any competent typist) prepares a *visual* proof as she makes the tape. The machine parity-checks each code automatically. And finished tapes can be double-checked (or quickly duplicated) by running them back through the Flexowriter's reader.

Along with Kearney & Trecker, the great majority of machine tool manufacturers have already standardized on 8-channel punched tape input. Take it from them: punched tape is the best NC input. And in punched tape, Friden is the leader.

THIS IS PRACTIMATION: Friden is the world leader in tape technology and the practical application of the automation it makes possible. For full information, call your local Friden Systems Representative. Or write: Friden, Inc., San Leandro, California.

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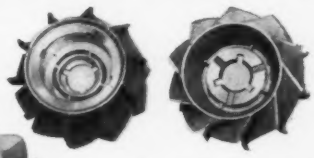
Friden

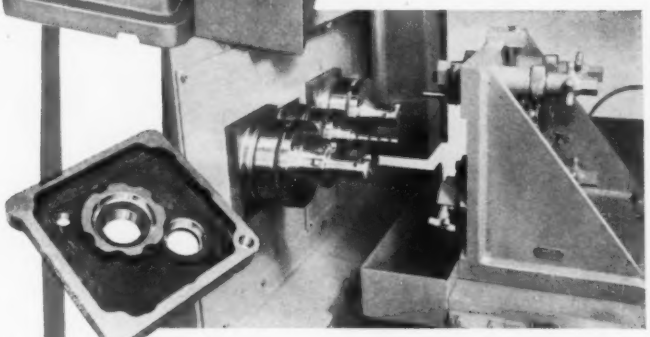
Sales, Service and Instruction Throughout the U. S. and World

Let the work size, operations, finish or output change . . .

Standard Ex-Cell-Os will meet your needs!



Double-end Model 752 (shown at left) finish-machines both sides of this torque converter stator in one cycle at a rate of 140 per hour. Standard tooling, spindles, and other components permit fast change-over from this job's boring, turning, facing, grooving and chamfering operations to any required single or multiple functions.



Close center-distances are held on this transmission pump cover, one of three different parts finished on a single-end Model 751 Precision Bore. Cross slide indexes during each cycle, and a common spindle bores the dowel holes. One or more Heavy Duty or Ultra-Precision Spindles can be used in place of the three Ex-Cell-O Square Body Spindles shown.

Modern Ex-Cell-Os represent over 30 years of specialization in Precision Boring Machines. Your Ex-Cell-O Representative has data on a wide variety of standard, special and building-block types to quickly provide optimum equipment utilization in your plant. Call him soon, or write direct for details.

61-16M

EX-CELL-O FOR PRECISION

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Machinery Division

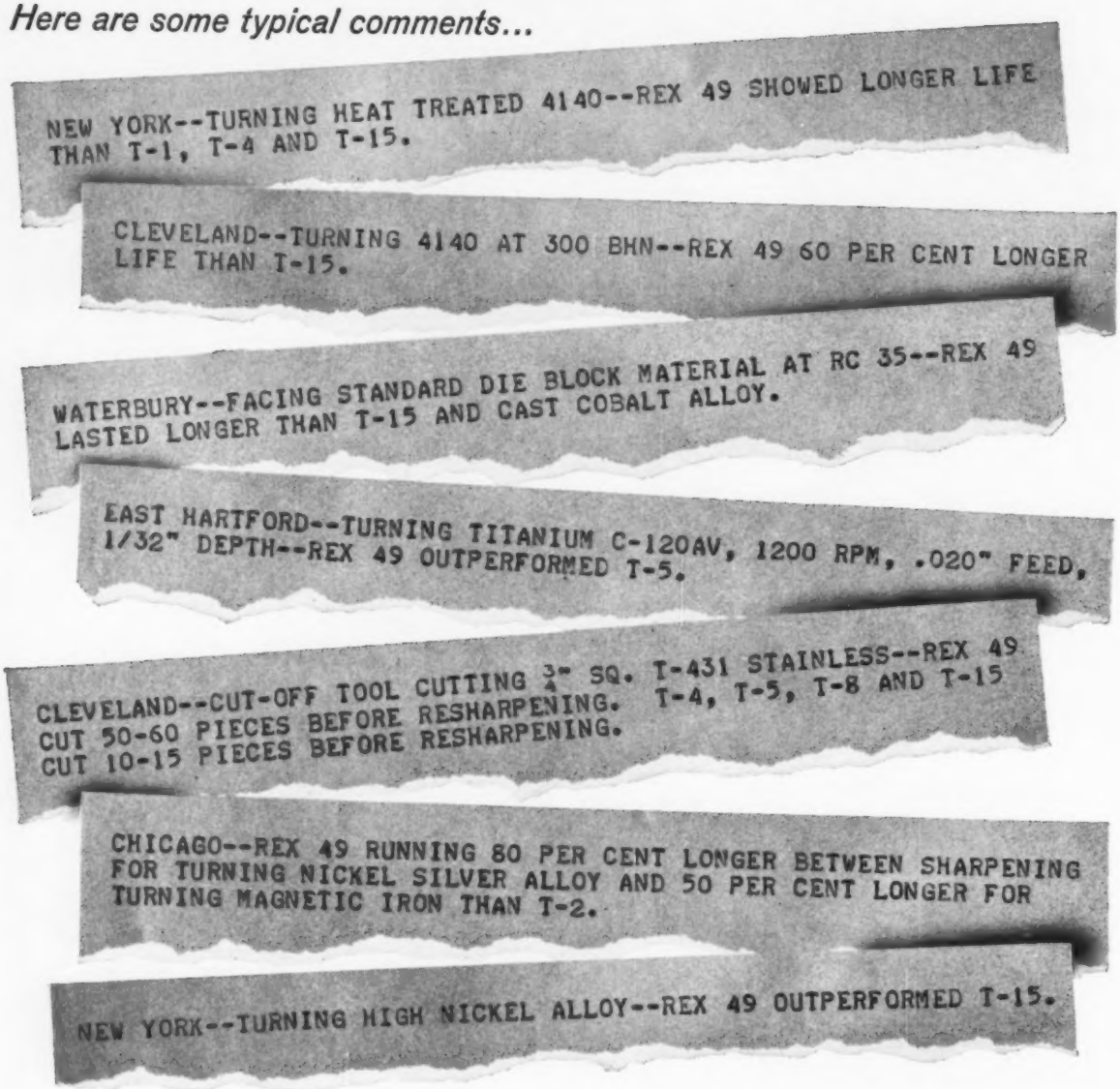
EX-CELL-O CORPORATION

DETROIT 32, MICHIGAN

For more data, circle this page number on Readers' Service Card.

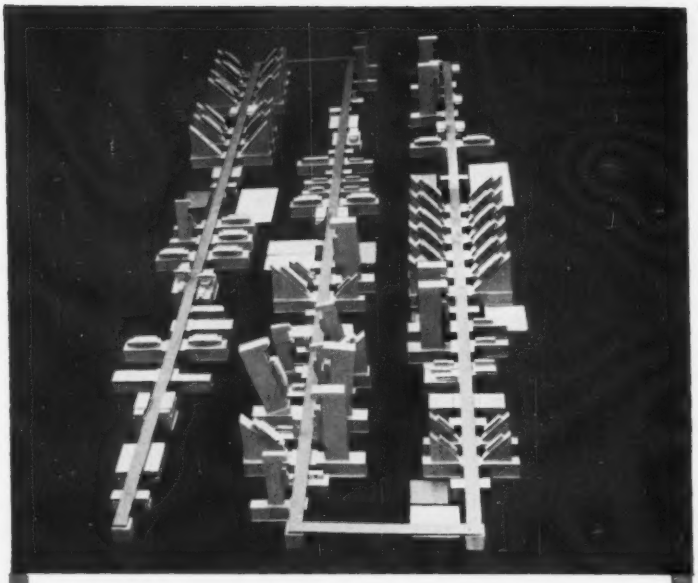
73% of first field reports indicate REX® 49 outperforms other high speed steels

Here are some typical comments...


NEW YORK--TURNING HEAT TREATED 4140--REX 49 SHOWED LONGER LIFE THAN T-1, T-4 AND T-15.
CLEVELAND--TURNING 4140 AT 300 BHN--REX 49 60 PER CENT LONGER LIFE THAN T-15.
WATERBURY--FACING STANDARD DIE BLOCK MATERIAL AT RC 35--REX 49 LASTED LONGER THAN T-15 AND CAST COBALT ALLOY.
EAST HARTFORD--TURNING TITANIUM C-120AV, 1200 RPM, .020" FEED, 1/32" DEPTH--REX 49 OUTPERFORMED T-5.
CLEVELAND--CUT-OFF TOOL CUTTING 3/4" SQ. T-431 STAINLESS--REX 49 CUT 50-60 PIECES BEFORE RESHARPENING. T-4, T-5, T-8 AND T-15 CUT 10-15 PIECES BEFORE RESHARPENING.
CHICAGO--REX 49 RUNNING 80 PER CENT LONGER BETWEEN SHARPENING FOR TURNING NICKEL SILVER ALLOY AND 50 PER CENT LONGER FOR TURNING MAGNETIC IRON THAN T-2.
NEW YORK--TURNING HIGH NICKEL ALLOY--REX 49 OUTPERFORMED T-15.

REX 49 is readily available from local Crucible steel centers. Call the Crucible technical service engineer nearest to you to find how you can benefit with REX 49. *Crucible Steel Company of America, Dept. HH20, Four Gateway Center, P. O. Box 88, Pittsburgh 30, Pennsylvania.*

CRUCIBLE STEEL COMPANY OF AMERICA



For economy, productivity, flexibility... EX-CELL-O BUILDING BLOCK UNITS!

- You get custom equipment, made from low-cost, standardized units.
- You can build simple one-way precision machines, or huge multi-station transfer machines.
- You can remove, relocate or add work stations to suit your production needs.
- You can arrange components for horizontal, angular, radial or vertical machining.
- You can partially or completely automate any sections.
- You can set up single or multiple functions—bore, counterbore, turn, drill, ream, face, chamfer and other operations.
- You can re-tool with standard Ex-Cell-O spindles, hydraulic power units and other accessories—and *know* all units will fit perfectly.
- You get faster delivery because standardization reduces engineering and build-up time.

If you're looking for manufacturing flexibility, look into Ex-Cell-O Building Blocks. Call your Ex-Cell-O Representative, or write for Bulletin 505911.

61-29M

EX-CELL-O FOR PRECISION

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Machinery Division

EX-CELL-O CORPORATION
DETROIT 32, MICHIGAN

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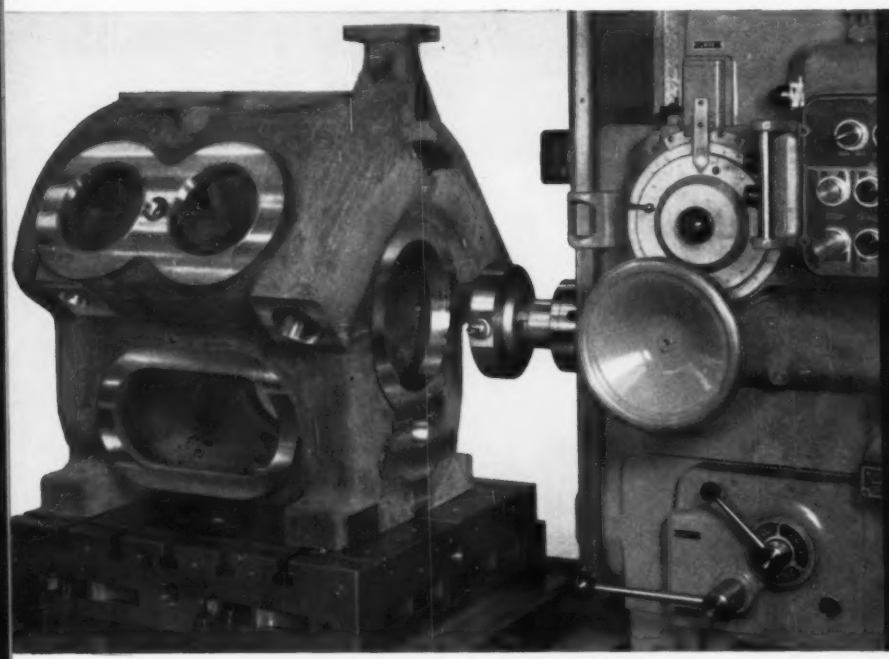
Gone to Fair street...

DE VLIEG MACHINE COMPANY, FAIR STREET • ROYAL OAK, MICHIGAN

Why did he drop everything and go? Because he couldn't afford not to. He had just received a very remarkable report on the DeVlieg JIGMIL and the DeVlieg Philosophy of Precision Machining. He's got to find out whether such tremendous cost-saving performance can really be true. If there's a better way of doing things, he wants to know about it . . . put it to work for his company. That's one reason why his company is so healthy . . . so far ahead of competition.

SOME OF OUR JIGMIL USERS

ACF Industries, Inc.
Allis-Chalmers Mfg. Co.
Allring-Landers Co. Inc.
Bell & Gossett
Bethlehem Steel Corp.
Brunner Corp.
Caterpillar Tractor Co.
Champlain Corp.
DeLaval Co.
The Deming Co.
Didde-Glaser, Inc.
Franklin Machine Co.
Gardner-Denver Co.
Harnischfeger Corp.
Hupp Aviation Co.
Hyster Co.
Ingersoll-Rand Corp.
International Harvester Co.
Koppers Co.



Basic Principles in the DeVlieg Philosophy of Precision Machining

- A Machine Tool capable of desired accuracies
- Correct Tool Geometry
- A Method of Tool Preparation and Maintenance

Only DeVlieg Delivers the Complete Package!

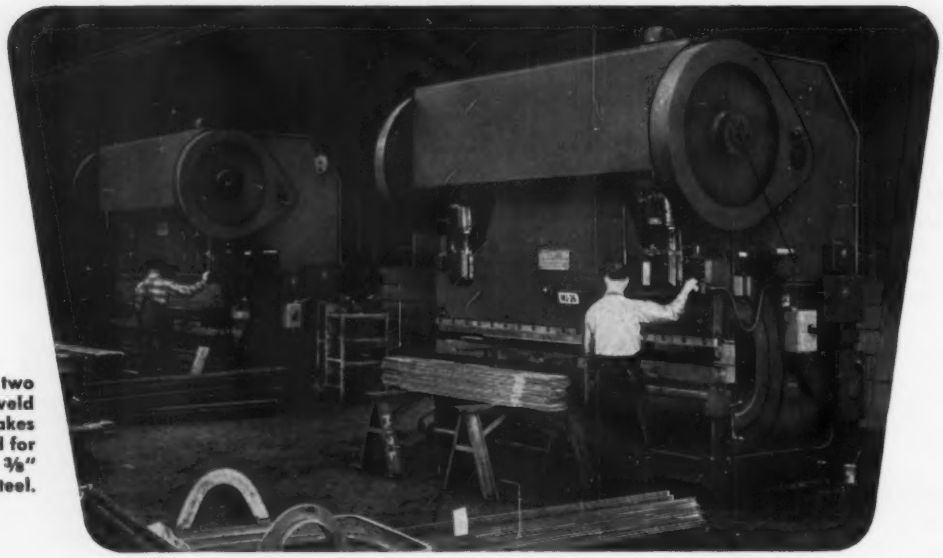
Seeing is believing. Compressor housing for an industrial air conditioning system being machined on a DeVlieg Spiramatic JIGMIL. Accurate holes and flat surfaces are extremely critical in the part to prevent leakage of Freon gas. Part is programmed on a model 3B-48 standard JIGMIL with 26″ x 26″ index table and Microbore tooling. Machining operations include complete rough and finish milling and boring in three set-ups of the part. The DeVlieg system provides a finished part in approximately five hours. Much faster than machining methods previously used!

Ladish Co.
F. Joseph Lamb Co.
LeTourneau-Westinghouse Corp.
J. Leukart Machine Co., Inc.
Manning, Maxwell & Moore, Inc.
Maro Precision Tool Co.
National Supply Co.
New Jersey Machine Corp.
Practical Machine Co.
Saco-Lowell Shops
Sandia Corp.
Union Carbide Nuclear Co.
Van Vlaanderen Machine Co.
York Div., Borg-Warner Corp.
Worthington Corp.

WILL YOU BE THE NEXT TO VISIT FAIR STREET

DeVlieg
SPIRAMATIC JIGMILS®
ACCURATE HOLES AND FLAT SURFACES IN PRECISE LOCATIONS

For more data, circle this page number on Readers' Service Card.



These two Steelweld Press Brakes rated for 12'-0" x 3/8" mild steel.

STEELWELD PRESSES and SHEARS aid Caterpillar Production

Steelweld Shear rated for 10'-0" x 1/2" mild steel.

Thousands of tons of steel of different thicknesses are sheared and formed on Steelweld Shears and Presses into various shapes required for the large volume of tractor equipment produced at the Joliet, Illinois, plant of Caterpillar Tractor Co. These items include scrapers, rippers, and bulldozer blades.

The heavy construction of Steelweld machines and many high quality features with which they are provided make possible continuous trouble-free performance. Their design includes a number of innovations which ease operation, speed production and enable accuracy to close tolerances.

The fact that Caterpillar has bought Steelweld Shears and Presses repeatedly and now has a large number of them is mute testimony to the satisfaction they are giving.

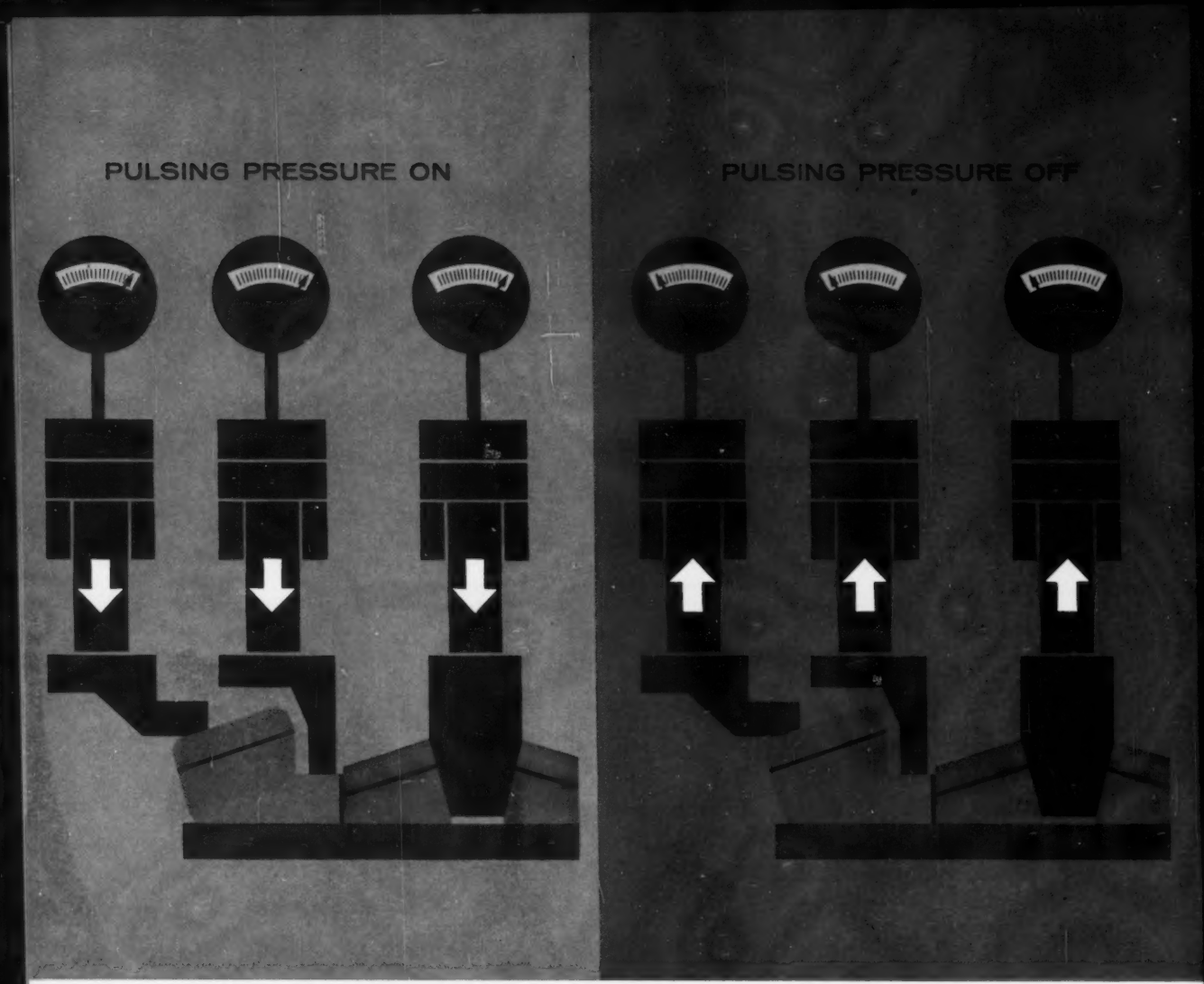
Free catalogs available.

STEELWELD

PRESSES and SHEARS

Steelweld Machinery includes: Mechanical & Hydraulic Shears and Press Brakes, One-, Two- and Four-Point Straight-Side Presses, Speed-Draw Presses.

STEELWELD MACHINERY DIVISION • THE CLEVELAND CRANE & ENGINEERING CO. • 5450 E. 281 ST. • WICKLIFFE, OHIO



New Quenching Machine pulsates to eliminate distortion

The pulsing feature of the No. 529 Quenching Machine allows the use of high pressures to control distortion of parts under quench. Pulsing, which is a way of alternately applying and releasing pressure on the part, allows for the natural contraction of the part . . . and eliminates stresses in the part-die relationship.

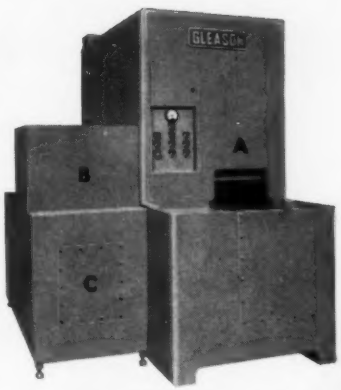
You get tremendous latitude in control of the quench, since as much as 200 gallons of oil can be pumped over the parts.

Simply preset the oil flow with valves and timers, and you have the following automatic cycle: start with a fast quench to set the part, switch to a lower rate; then finish with a rapid quench or vary the sequence any way you wish.

The hydraulic system has a maximum of 1000 pounds of pressure per square inch; a combined total of 50,000 pounds of pressure is available on this machine.

You can handle parts up to 10½ inches in diameter and 4 inches high in the No. 529 Quenching Machine. And it is available in three variations; by adding units as shown in the caption, production is greatly increased.

Drop us a card, and we'll send you more data on specifications and operation.



The basic No. 529 Quencher (A) is manually loaded and unloaded. Automatic unloading (B) is easily added. An auxiliary quench chamber (C) can be added for high production work.

GLEASON WORKS

1000 UNIVERSITY AVE., ROCHESTER 3, N. Y.

NEW cleco 600

horizontal grinder

delivers maximum horsepower on the work!

Field tests on the new Cleco 600 Series Horizontal Grinder clearly show that here is an air tool that will be in great demand!

Operators like its feel . . . its lighter weight . . . balance . . . vibration-free performance . . . power on the job.

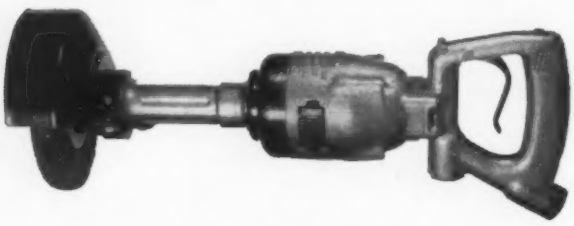
They like the one piece spindle and motor casing, line-bored for perfect alignment . . . the externally adjustable governor . . . easy throttling . . . 360° directional exhaust . . . quick-response governor for more positive governor action — stainless steel governor spider that resists corrosion.

Typical comment: A lightweight grinder for heavy-duty jobs!

The Cleco 600 Grinder is available in speeds of 4500, 6000 or 9000 RPM, with lever throttle, wing nut throttle or spade handle.

And many parts are interchangeable with Cleco's comparable vertical grinder. Greater savings in stocking of repair parts.

Let your Cleco representative arrange for a demonstration-tryout today. Then you will see why this tool is a high-production tool! We like to make them . . . you will like to use them!



"quality tools engineered for industrial progress"

CLECO AIR TOOLS

A DIVISION OF REED ROLLER BIT COMPANY
P. O. Box 2541, Houston 1, Texas, U. S. A.
IN CANADA: Cleco Pneumatic Tool Company of Canada, Ltd.
927 Millwood Road, Leaside (Toronto) Canada

For more data, circle this page number on Readers' Service Card.

Production Pointers

from GISHOLT

More cost-cutting IDEAS—
to help you

CALIFORNIA PRESS CUTS TIME 58% ON LARGE QUILL SHAFTS

JETracer . . . smart tooling simplifies complex jobs

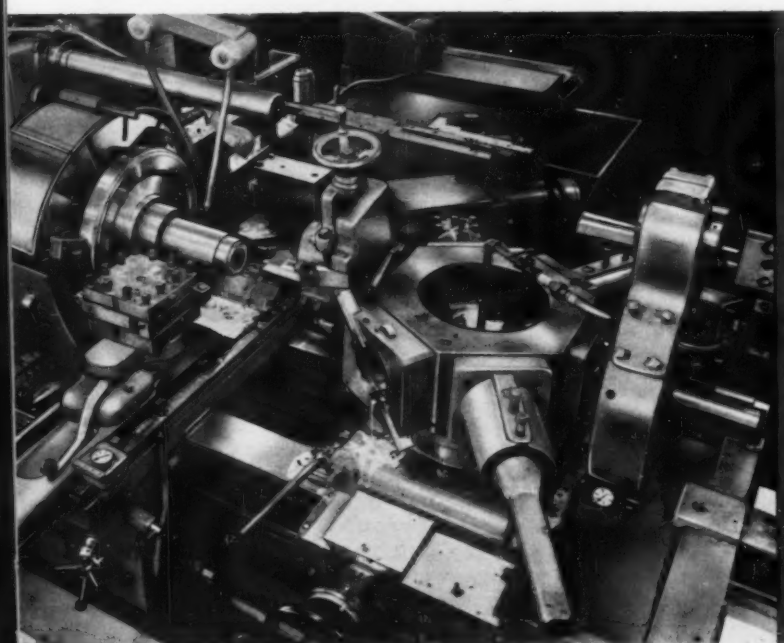
California Press Manufacturing Co., San Francisco, California, uses a Gisholt MASTERLINE® 5L Saddle Type Turret Lathe to produce a variety of large, heavy parts. Other jobs, such as large-diameter, thin-wall rings, are also machined to close tolerances without distortion. Whether your parts are large or small, their method will provide some cost-cutting answers.

Setup and machining is simplified by a JETracer on the rear of a bridge-type cross slide and a cross-feeding hex turret. Tooling costs are reduced because only standard hex turret tools (in most cases), and simple flat templates (to control the JETracer's single-point tool), are needed to provide accuracy and fine finish. Insert-type tool bits keep down-time at a minimum. Dial indicators speed positioning.

This arrangement saves 7½ hours on the quill shaft shown. Material is cast steel, SAE 4140, annealed and heat-treated to 22-25 Rc. To eliminate possible distortion, it is machined in three operations. *One* tool setup handles all *three*, with only minor tool adjustments between operations. Total f.t.f. time . . . only 5½ hours. Details are given in the photo captions.

Smart setup cuts quill shaft machining time 58%. JETracer and C/F hex turret eliminate costly form tools . . . minimize operator skill . . . improve accuracy . . . simplify inspection, for similar saving on all parts.

For information on 5L and JETracer, circle No. 756.



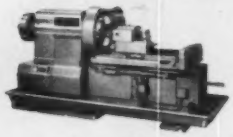
QUILL SHAFT (20¾" Diameter, 15¾" Long) MACHINED OVER-ALL IN 3 OPERATIONS WITH SETUP SHOWN AT LEFT

Operation 1—rough quill end: hex turret—rough turn quill with special holder (center of photo) and complete 11" long, 3⅛" bore; square turret—rough turn various quill diameters, face, form, undercut back of flange removing up to 1" stock. Time . . . 60 minutes f.t.f.

Operation 2—rough and finish flange end: hex turret—multiple head (far right) turns O.D., co-bores and forms . . . other stations machine various other steps in bore; square turret—finish all fit diameters, step faces, chamfers and radii. Time . . . 3 hours f.t.f.

Operation 3—finish quill end: JETracer finish traces length of quill (two passes) with center support from hex turret; square turret—undercut, groove and thread quill end using side carriage chasing attachment; hex turret—finish bore and chamfer. Time . . . 1½ hours f.t.f.

PREMATURE MACHINE OBSOLESENCE SOLVED



Simplimatics have flexibility for present and future needs

If you have parts that call for special or multiple-spindle machines, you'll want to study this story. The decisions reached by a major automotive manufacturer may provide some answers to your problems.

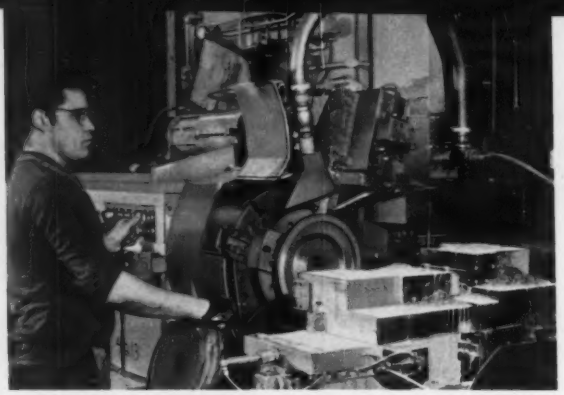
In tooling up to produce 5 different sizes of flywheels, the advantages, costs, and production rates of standard and special or multiple-spindle machines were carefully weighed. Eight *standard* Simplimatics were purchased because they met the requirements listed below at *standard* machine prices.

FLEXIBILITY . . . Each Simplimatic has a wide, screw-fed platen upon which *standard* independent slides with tool blocks can be positioned to suit the work. Two machines have a headstock-mounted auxiliary slide for machining behind the leading edge of the work. To meet varying production needs, all tool blocks for front, rear, and auxiliary slides have locating keyways and stops and are *completely interchangeable* between machines.

MINIMUM DOWN-TIME . . . Templates were supplied so that all but the boring tools could be *pre-set* in master blocks. Throw-away insert tools are used wherever possible. When a tool dulls, the operator can quickly index to a new edge or replace it with another pre-set tool, locating against ground surfaces in the tool block.

OBSOLESENCE . . . Tool blocks can be easily modified with minimum effort and cost to produce any existing or *future* part design.

PRODUCTION . . . Simplimatic completes maximum surfaces per cycle. Caption provides machining details.

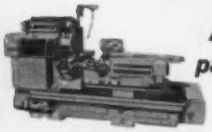


First operation on 13.250″ flywheel. Table feed bores, turns O.D. from front slide . . . standard movement faces. Table feed co-bores and shaves bevel from rear slide . . . standard movement faces, chamfers and shave-turns ring gear diameter. Auxiliary slide sizes ring gear diameter. Eleven tools machine 13 surfaces at approximately 300 sfm. Time . . . only 1.30 minutes.

Simplimatics give you top production rates, peak versatility at standard machine prices. Tooling . . . not machine . . . can be modified at low cost for new work.

For information on Simplimatic, circle No. 757.

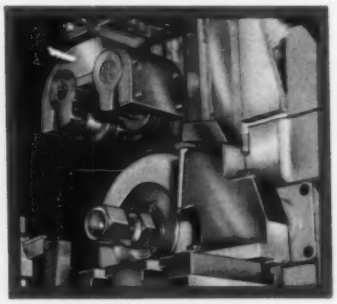
L&L COMBINES OPERATIONS FOR 60% TIME SAVINGS



AR Turret Lathes produce finished parts from bar stock—automatically

This setup shows how you can reduce costs on bar work—involving both internal and external threading, forming and cut-off operations. With it, L & L Manufacturing Company, Warren, Michigan, cut machining time on intermediate size runs an average of 60% on over 1500 different types of pipe and tube fittings, made from round, square, and hex C-1119 steel bar stock.

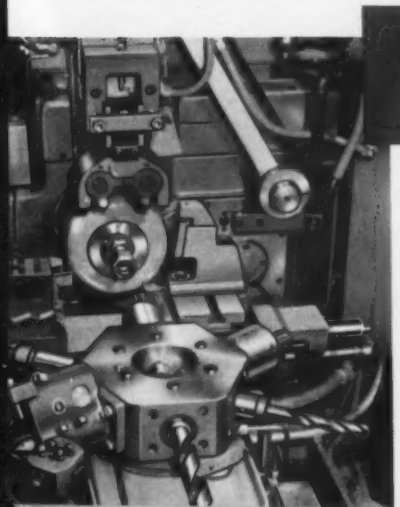
Equipment selection played an important part in obtaining these savings. Competitive machines were evaluated with these objectives in mind: Complete automatic operation; use of solid taps, self opening dies, and thread rollers during same cycle; tooling capacity to complete parts in one cycle; range and number of speeds for maximum metal removal and optimum tool life; rigidity for forming cuts; quick setup; and initial cost.



Overhead slide rolls thread behind hex shoulder. Used for cut-off operations on certain other parts.

As a result, three Gisholt 5AR Turret Lathes were purchased. One 4½″ and two 2½″ capacity machines were needed to handle product mix. All were equipped with an extra tool slide, mounted on the headstock, above the spindle. One 2½″ machine has an octagon turret. This gave L & L a choice of 9 or 11 tooling stations so that even the most complex parts could be completed in one machining cycle.

The entire cycle, including operation of collet chuck and bar feed, is automatic and repeats until new bar stock is needed. Stock stop, drilling, reaming, tapping or O.D. threading is handled from the hex or octagon turret. The overhead slide is used to roll threads on some parts with forming and cut-off done by front and rear cross slide tools. On other parts, forming is handled by cross slide tools with cut-off from the overhead slide. A typical sequence is given in the photo caption.



Tooling for 2″ pipe reducing connector (Inset) made from hex bar stock. Tapered O.D. behind shoulder is rough-formed as machined part is cut-off from front cross slide. Rear cross slide finish forms tapered O.D. holding to .001″. Turret tools start-drill, radius and drill large and small bores, taper-ream and tap large bore. Overhead slide rolls thread behind shoulder. Stock advances to turret stop and cycle repeats. Time . . . 2.5 minutes f.t.f.

AR offers complete automatic cycle on bar work . . . cuts time 60%. . . combines operations. . . saves extra handling . . . improves accuracy. Operator can handle two machines.

For information on AR Turret Lathes, circle No. 758.

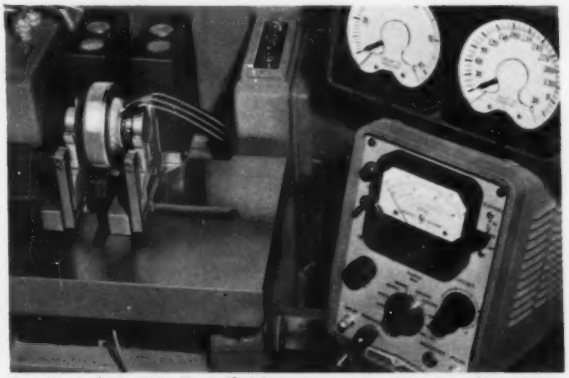
SPEED UP AND SIMPLIFY SMALL PARTS BALANCING

...New High Speed Balancer saves time, improves accuracy at low cost...

Producing small, high-speed parts or assemblies? You can now measure and correct for unbalance in parts weighing from ½ to 8 oz., or from 8 oz. to 10 lbs., rotating at any speed between 2,000 and 12,000 RPM.

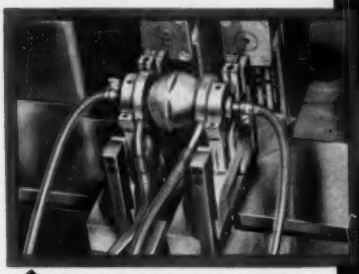
The HS-2 Balancer shown, is used for two-plane balancing of electrically self-driven gyro rotors and air-driven gimbal and gyro assemblies. It cut previous time in half and gave three times greater accuracy. Support fixtures permit quick changeover for additional time savings.

Except for method of drive, both workpieces are handled in the same manner. During each revolution, an abrupt change from dark to light finish on the work O.D. triggers a photo tube. This permits accurate speed indication on a tachometer and close regulation at 6,500 RPM for maximum accuracy. It also offers an exact reference point for locating angle of unbalance. After acceleration, angle and amount of unbalance is read in both planes in only 30 seconds. Meters eliminate all operator "guessing".



Rotation of electrically self-driven gyro rotor triggers photo tube under part to show speed on tachometer (lower right), and operate angle meter (top right).

Correction drilling of gyro rotor uses dial indicator to match depth on amount meter.



▲ Air-driven gimbal and gyro assembly. Balancing sequence, including correction and inspection, takes less than 15 minutes.

A separate correction drilling unit is used to meet the .000020 oz. inch tolerance. To correct in each plane, work is placed in a fixture and indexed until the indicated angle is under the drill. The operator refers to a dial indicator as he drills to the depth shown on the amount meter. One correction pass in each plane takes less than 4 minutes. Additional passes may be necessary if unbalance is excessive or if material is not homogeneous. Work returned to balancer for final inspection.

HS production rates depend on part—range from 1 minute on fans and wheels to 4 minutes on armatures. Includes time to accelerate, locate, measure, stop, correct, inspect.

For information on HS Balancers, circle No. 759.

LOW-COST METHOD FINISHES MULTIPLE SURFACES

Completes one to six diameters during fast automatic cycle...

If you grind bearing and seal diameters on shafts or spindles, the savings offered by Superfinish will surprise you. The finishing of tractor transmission input shafts points up some of the chief advantages.

LOW COST . . . Here, a Model 51 General Purpose Superfinisher, using inexpensive abrasive sticks, handles a variety of parts. Machine and tool cost is only a fraction of what would be required if any other method were used to meet the close tolerance, fine finish requirements of the manufacturer.

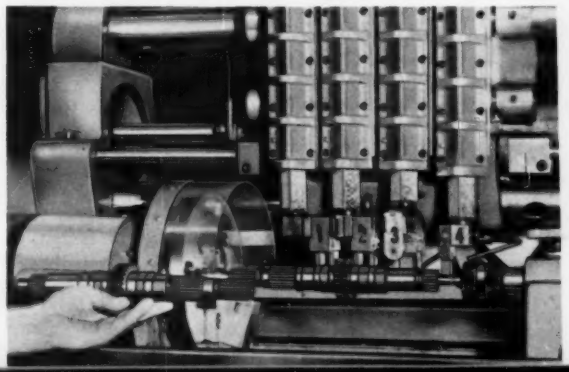
VERSATILITY . . . Extra quills can be added to complete several diameters simultaneously, with no increase in cycle time. Four quills are used on the part shown. Two off-set holders carry two stones each—the others carry one stone—so that six diameters are completed at the same time. These are reduced from 40 to 8 micro inches rms in only 50 seconds, f.t.f. Any other method would require more expensive tooling and/or several operations to do the same amount of work.

IMPROVED METALLURGY AND GEOMETRY . . . These parts are SAE 8630 steel. Specified hardness of 60-63 Rc must be maintained for reliable operation. They are rough ground to size and a 40 micro inch rms finish. Grinding heat anneals a microscopic layer on the surface. Superfinish removes this layer and exposes the true base metal. No heat is generated so hardness is unchanged. Because Superfinish is an area-contact process, roundness is improved and longer-pitch waviness is corrected. Peaks that break down and cause premature wear are removed, leaving plateaus for greater bearing area and valleys to retain lubricant.

Superfinish costs less . . . handles multiple surfaces with no increase in cycle time. Improves metallurgy and part geometry for greater product reliability.

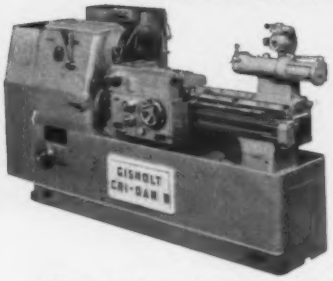
For information on Superfinish, circle No. 760.

Tractor transmission input shaft (SAE 8630 steel . . . 60-63 Rc) held between centers, driven from spline. Off-set holders 1 and 2 carry two stones each . . . finish four diameters. Holder 3 completes 1¾" long diameter. Off-set holder 4 handles one diameter. Six stones work together reducing 6 surfaces from 40 to 8 micro inches rms. Production . . . 48 parts per hour.



HOW TO BOOST PROFITS ON THREADING OPERATIONS

CRI-DAN Technique offers savings of 30% to 80% over conventional methods



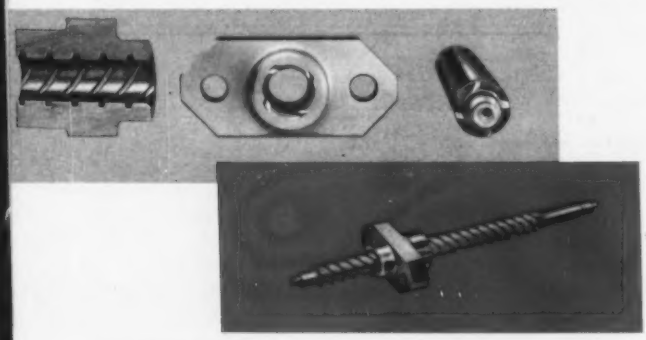
The photos on this page illustrate some of the threading operations you can do on a Gisholt Cri-Dan B Automatic Threading Lathe. Note the wide variety of work, the different threads and materials, and the fast threading times.

These jobs are simple on the Cri-Dan B—yet, each presented problems that could only be solved at high cost in equipment, tooling and time, using any other method. They prove *you* can use inexpensive, single-point carbide tools to produce simple or complex *quality* threads . . . *automatically*.

With Cri-Dan you'll have fast 15-minute setup, low tool cost, and versatility that permits combining precision threading with tracing, turning, boring or facing cuts in one automatic cycle. This means higher profits on small lots as well as long production runs.

Compare these threading times with your own, on similar work. How much could *you* save—with a Cri-Dan B?

For information on Cri-Dan B, circle No. 761.



AIRCRAFT RUDDER PEDAL ADJUSTING SCREW (SAE 4130-25-30Rc) AND NUT (Aluminum Bronze) for Lockheed Model C-130 Airplane

OPERATION

Screw: Generate ½"–10 4-start Acme Thread with 1" lead .060" deep for length of 5¾".

Nut: Generate matching 4-start internal thread.

TIME

Screw: 25 minutes f.t.f.
Nut: 15 minutes f.t.f.

SAVINGS

Screw: 65 minutes per part (previously milled).

Nut: Difference between cost of single point carbide tool and $490.00 tap for this job.

CUSTOMER

Orlando Machine Co., New Smyrna Beach, Florida.

SPOOL VALVE (440C Stainless)

OPERATION

Generate tapered 20 TPI NF Class 3 thread in .4675" bore right up to internal face.

TIME

30 seconds to thread—production 35 parts per hour.

SAVINGS

5.03 minutes per part—467% compared to tapping. Rejects eliminated (were as high as 20%), longer tool life (to 75 parts per grind).

CUSTOMER

Acme Industrial Co., Chicago, Illinois.

BEARING ADJUSTMENT NUT (cast iron)

OPERATION

Turn, chamfer front O.D., generate 12 TPI, .054" deep thread on 6½" O.D., face and chamfer rear O.D.

TIME

1.8 minutes f.t.f.

SAVINGS

60% on machining and threading time; replaced two machines; improved quality.

CUSTOMER

Mack Trucks, Inc., Plainfield, New Jersey.

ZOOM OPERATING SLEEVE (Aluminum); FRONT CELL LENS (Aluminum) for 8 mm. ZOOMATIC MOVIE CAMERA

OPERATION

Sleeve: Bore, generate 2-start, .0625-pitch, .125" lead, Class 4 16NS thread in 1.610" center section of bore.

Lens: Turn rear pilot diameter, generate mating threads on 1.610" leading diameter.

TIME

Sleeve: 20 seconds f.t.f.
Lens: 20 seconds f.t.f.

SAVINGS

50% time reduction — improved quality.

CUSTOMER

Bell and Howell, Chicago, Illinois.

GISHOLT
MACHINE COMPANY
Madison 10, Wisconsin, U.S.A.

The Gisholt Round Table represents the collective experience of specialists in the machining, surface-finishing and balancing of round and partly round parts. Your problems are welcomed here.

No. 7-861
803

Turret Lathes • Automatic Lathes • Balancers • Superfinishers

Threading Lathes • Packaging Machines • Masterglas Molded Plastic Products

Printed in U.S.A.

Get all the advantages—find out how much faster—better—you can do with Inland Ledloy® steels. Go ahead...we mean it...clobber it!

■ Push your machines as far as they'll go, then see for yourself—speeds and feeds like you've never seen before—the easiest tolerance control you've ever had—greater production per tool change than you ever thought possible.

■ Inland pioneered in the production of leaded steels—has worked hand in hand with metal-working shops to achieve the finest, most machinable steels in the world. Send today for your free copy of the booklet, "Properties of Ledloy Steels," and be sure you use Inland Ledloy leaded steels—you can count on them because they're backed up by more than 20 years of continuous research, development and practical experience. Ledloy steels are available from your Cold Drawer or your local Steel Service Center.

LEDLOY® STEELS CAN TAKE IT!

the world's most machinable steels **INLAND STEEL COMPANY**

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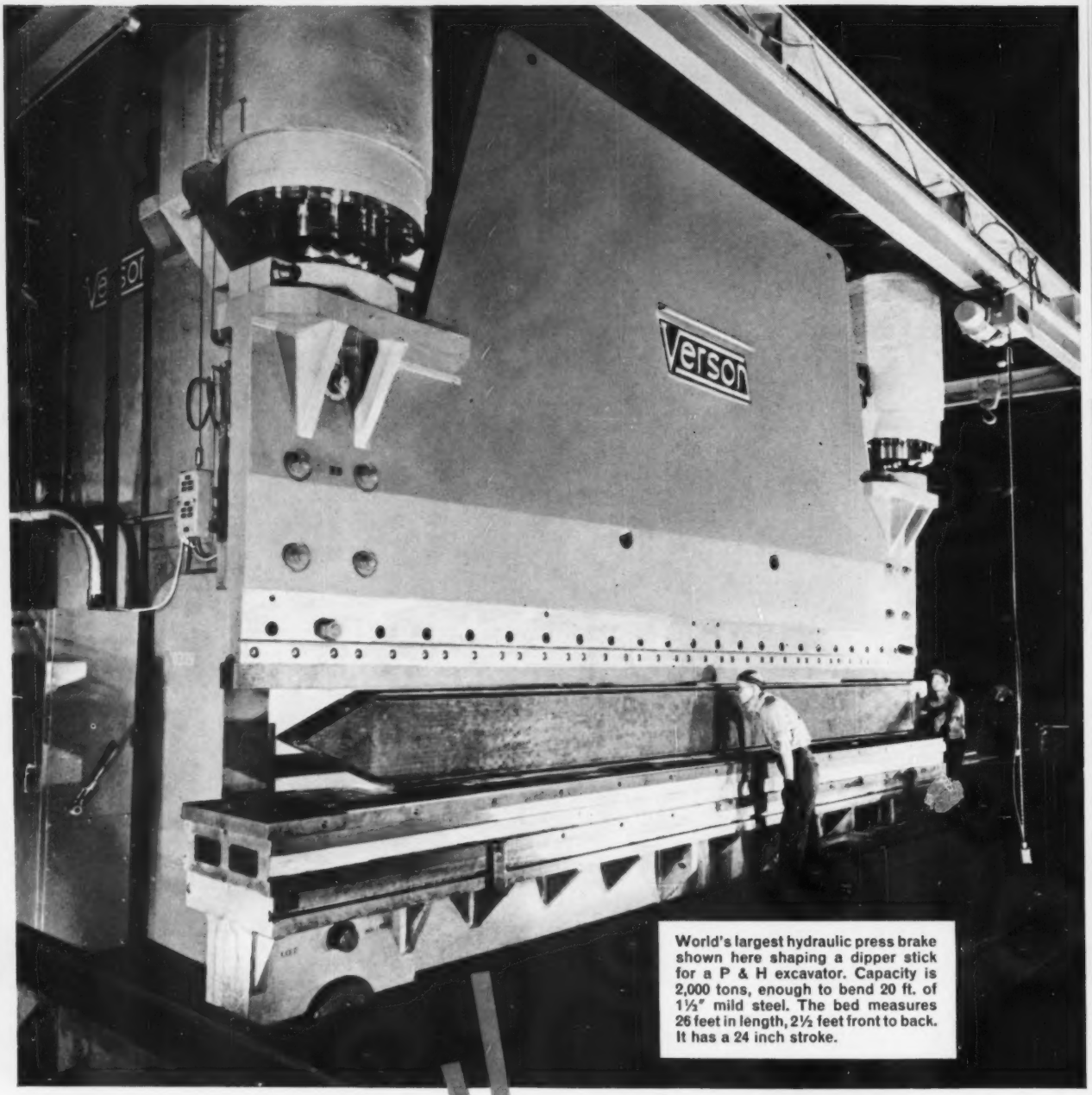
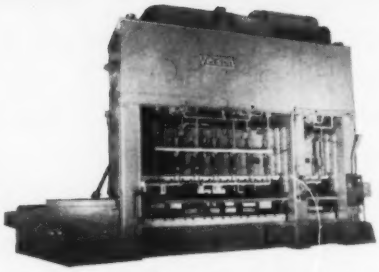


World's largest hydraulic press brake shown here shaping a dipper stick for a P & H excavator. Capacity is 2,000 tons, enough to bend 20 ft. of 1½" mild steel. The bed measures 26 feet in length, 2½ feet front to back. It has a 24 inch stroke.

-**Verson**-PRESSES
designed and built
to help you meet and beat
"Tight Competition"



Verson Transmat Presses are single presses with multiple die stations. The piece is transferred by mechanical fingers. Whenever 4,000 or more identical stampings, requiring four or more operations, are needed daily, you should investigate Transmat production.

TWO THOUSAND TON Verson – HYDRAULIC PRESS BRAKE helps Harnischfeger Corp. meet "tight competition"

To meet and beat the tight competitive conditions that exist in virtually every market today it is essential to produce better products more efficiently to prosper. For example, one of the steps taken by Harnischfeger Corp. of Milwaukee to help meet "tight competition" has been the installation of the giant Verson hydraulic press brake illustrated on the front cover and at the left.

With 2,000 tons of metal forming capacity, the Verson machine enables one operator and a helper to perform in one bending operation, many of the same jobs that previously required as many as five strokes with conventional machines. Additionally, the new brake permits increased use of higher grades of alloy steel (super-strength) than normally would be practical from a production standpoint.

The Verson brake is versatile, too. Harnischfeger uses it on a full two shift basis for shaping trolley sections for overhead cranes, excavator dipper sticks, bucket shells, cable drums, cab base frames and other components for widely diversified "P & H" products.

Henry Harnischfeger, president of the Milwaukee firm which manufactures "P & H" products in 16 plants throughout the United States and abroad says, "By improving quality without increasing costs, we feel we're advancing our competitive position through the best and most fool proof method ever devised. We fully expect that the press brake will pay important dividends for many years to come—both to our customers and to ourselves."

How's your competitive position? If it needs shoring up anywhere along the line it may pay you to talk to a Verson production specialist. He will be pleased to show you how equipment designed and built to help meet "tight competition" can pay big dividends to *you* and *your* customers.

Call or write, today.

The 24 page catalog G-60 describes representative models of Verson's entire line of mechanical and hydraulic presses and press brakes. Write for your copy, today.

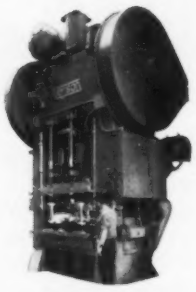
Verson

Originators and pioneers of allsteel stamping press construction

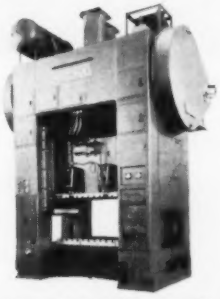
VERSON ALLSTEEL PRESS COMPANY

9309 S. Kenwood Avenue, Chicago 19, Illinois • 8300 S. Central Expressway, Dallas, Texas

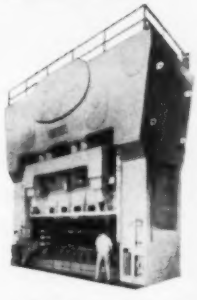
MANUFACTURERS OF MECHANICAL AND HYDRAULIC PRESSES AND PRESS BRAKES • TRANSMAT PRESSES • IMPACT MACHINING PRESSES
TOOLING • DIE CUSHIONS • VERSON-WHEELON HYDRAULIC PRESSES • HYDRAULIC SHEARS • PLASTICS MOLDING PRESSES



Verson Impact Machining Presses apply the principles of cold extrusion to a wide variety of steel and non ferrous piece parts that formerly had to be made by metal removal processes or hot forged. Saves on material . . . saves on machining.



Verson mechanical and hydraulic presses are furnished in the widest variety of types and sizes to meet standard needs and the most specialized requirements. Capacities range from 75 tons up. Bed areas range upward to the very largest.



Verson also offers a wide range of special purpose presses and equipment such as the mechanical double action press shown above—the largest of its kind in the world. For recommendations, send an outline of your requirements.

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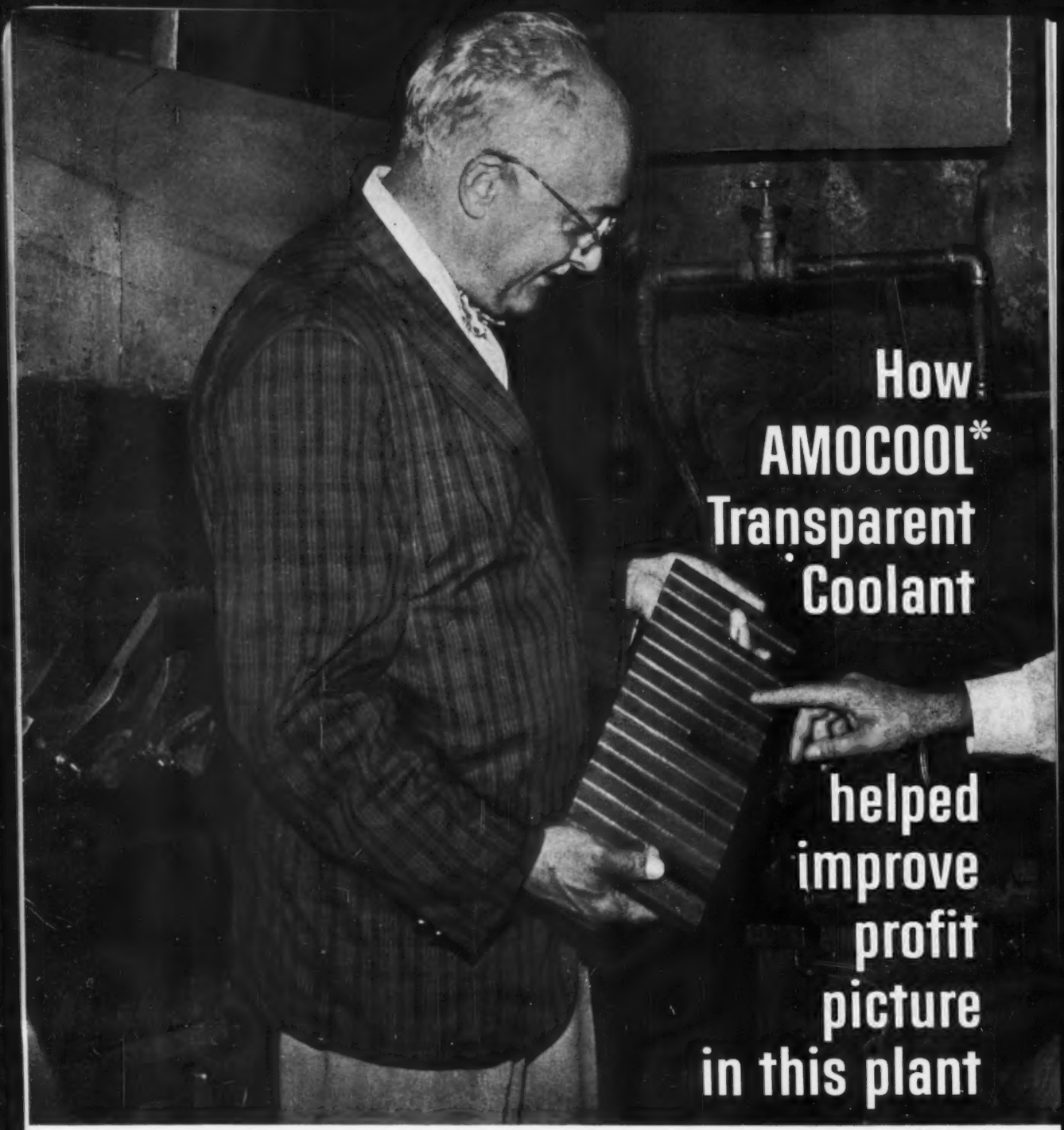
For more data, circle this page number on Readers' Service Card.



How AMOCOOL* Transparent Coolant helped improve profit picture in this plant

*Trademark

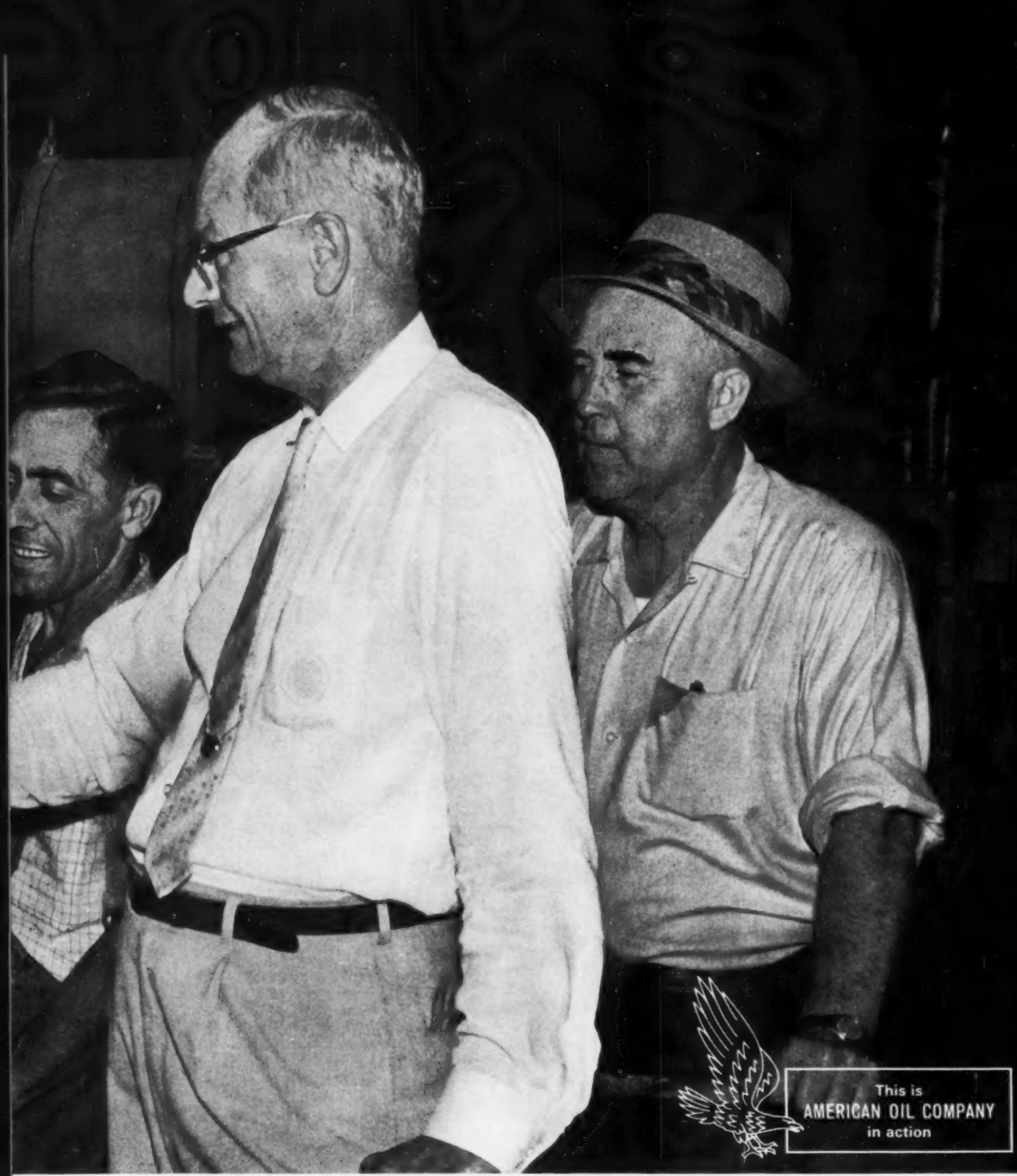
BY PAUL E. "PAPPY" STRATTON

About the Author. "Pappy" Stratton has been providing technical help on lubrication and metalworking problems to customers in the Detroit area for nearly all of the twenty-five years he has been working for the company. In addition to having this store of practical experience to help him, Pappy has completed the Company's Sales Engineering School.

* * *

By using a soap-base grinding compound, Detroit Edge Tool Company was getting excessive corrosion and rust on work and grinding machines. Oil vapor was collecting on machines and on the ceiling, causing dirty working conditions. Most important, high wheel loading was causing frequent down-time for wheel dressings.

We worked out a test program on AMOCOOL Transparent Coolant with the management. On our first test on one surface grinder, feed pressure was cut substantially while at the same time metal removal was increased.



Eliminate reworking because of rust, reduce wheel loading and extend intervals between wheel dressings; do these and you increase profit per unit, explains Detroit Edge Tool president, Dan Ebbing, to P. E. "Pappy" Stratton of American Oil. Plant manager, John Yonker (right) and Sam Vineh, operator, look on.

The cost of reworking parts to remove rust was eliminated. Time required to clean machines to get rid of the odor was cut in half. Less wheel loading and fewer wheel dressings have upped production and reduced costs. Our test program paid out in an improved profit picture. All grinding and drilling equipment has been converted to AMOCOOL Transparent Coolant.

Would you like this kind of technical help to assist you in improving profits? Get it by calling the American Oil Company office nearest you.

Quick facts about

AMOCOOL
Transparent Coolant

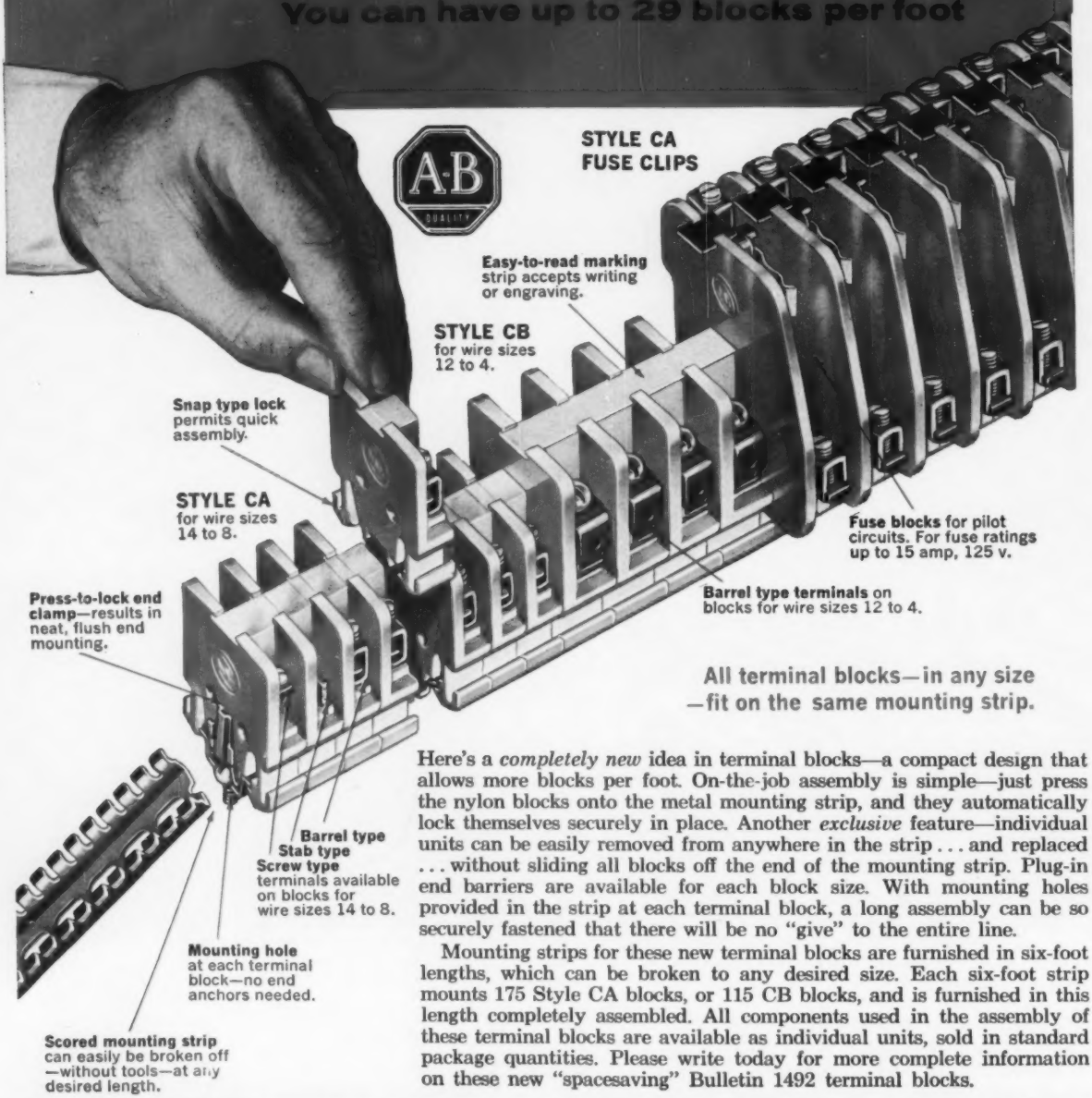
- Clear, transparent fluid
- Controls corrosion on work and machines
- All chemical. Does not support bacteria growth
- Unaffected by humidity
- Fire resistant
- Odorless

AMERICAN

AMERICAN OIL COMPANY
910 South Michigan Avenue
Chicago 80, Illinois

New ALLEN-BRADLEY BULLETIN 1492 SNAP-ON TERMINAL BLOCKS *save space*

You can have up to 29 blocks per foot


A-B
QUALITY
STYLE CA
FUSE CLIPS
Easy-to-read marking strip accepts writing or engraving.
STYLE CB
for wire sizes 12 to 4.
Snap type lock permits quick assembly.
STYLE CA
for wire sizes 14 to 8.
Fuse blocks for pilot circuits. For fuse ratings up to 15 amp, 125 v.
Barrel type terminals on blocks for wire sizes 12 to 4.
Press-to-lock end clamp—results in neat, flush end mounting.
Barrel type
Stab type
Screw type
terminals available on blocks for wire sizes 14 to 8.
Mounting hole at each terminal block—no end anchors needed.
Scored mounting strip can easily be broken off —without tools—at any desired length.

All terminal blocks—in any size —fit on the same mounting strip.

Here's a *completely new* idea in terminal blocks—a compact design that allows more blocks per foot. On-the-job assembly is simple—just press the nylon blocks onto the metal mounting strip, and they automatically lock themselves securely in place. Another *exclusive* feature—individual units can be easily removed from anywhere in the strip . . . and replaced . . . without sliding all blocks off the end of the mounting strip. Plug-in end barriers are available for each block size. With mounting holes provided in the strip at each terminal block, a long assembly can be so securely fastened that there will be no "give" to the entire line.

Mounting strips for these new terminal blocks are furnished in six-foot lengths, which can be broken to any desired size. Each six-foot strip mounts 175 Style CA blocks, or 115 CB blocks, and is furnished in this length completely assembled. All components used in the assembly of these terminal blocks are available as individual units, sold in standard package quantities. Please write today for more complete information on these new "spacesaving" Bulletin 1492 terminal blocks.

ALLEN-BRADLEY

Member of NEMA

Allen-Bradley Co., 1331 S. First St., Milwaukee 4, Wis. • In Canada: Allen-Bradley Canada Ltd.

QUALITY MOTOR CONTROL

BOSTON Gear® QUALITY . . . OPTIMOUNT® ADAPTABILITY

largest selection of standard models **from stock**
simplifies design for speed reduction economy

Helical geared Ratiomotors and Reductors – single or double reduction.
For 1/6 to 15 HP drives. Horizontal or vertical base mounted, or shaft mounted.
680 mounting combinations **from stock** – meet any in-line need.
Furnished ready to install, by local Distributors.
Specify **OPTIMOUNT.** Save extra cost of special gearhead motors.
Save design time. See Catalog 57 for complete listings.
IN STOCK at your nearby DISTRIBUTOR

BOSTON Gear®

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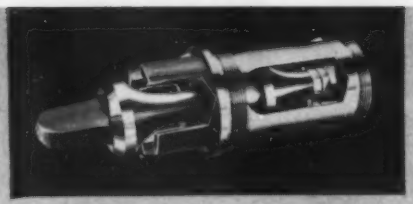
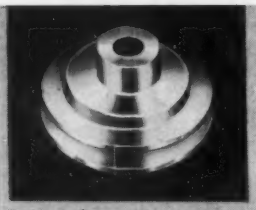
Quincy 71, Mass.

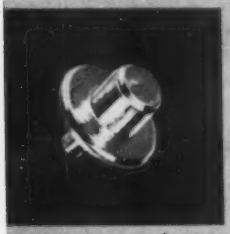


10% faster
Carpenter No. 5 (Type 416)

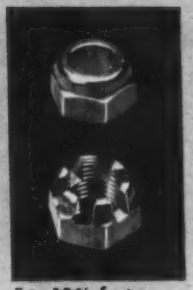


Rejects down 25%
Carpenter No. 5 (Type 416)

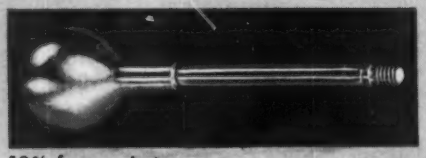
Production up 25%
Carpenter No. 5 (Type 416)



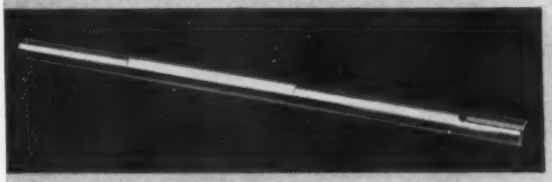
18% more production
Carpenter No. 8
(Type 303)



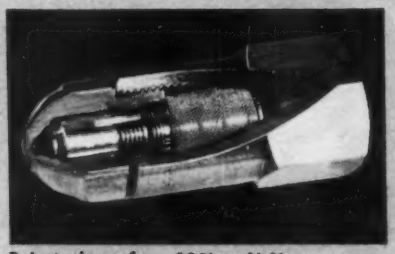
5 to 10% faster
Carpenter No. 8 (Type 303)



10% fewer rejects
Carpenter No. 8 (Type 303)



Machining cost cut 50%
Carpenter No. 8 (Type 303)



Rejects down from 10% to ½%
Carpenter No. 5-F

More profitable production... the No. 1 benefit of *Carpenter* stainless

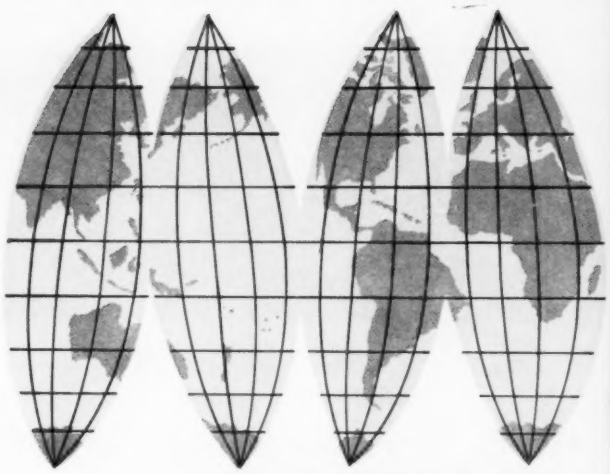
Free-Machining Stainless Steels by Carpenter start to prove their superiority right from the first production records. Seven of the eight examples in the illustration had a chance to use other steels first, then switched to Carpenter. The other used Carpenter first, then substituted another steel during emergency. He was quick to return to Carpenter.

Availability? Never Better! You can depend on rush delivery of Stainless No. 5 (Type 416) and No. 8 (Type 303) from your Carpenter Mill-Branch Warehouse, Office or Distributor. Build more profit into your production with Carpenter Free-Machining Stainless Steels.

Carpenter steel

you can make it ***consistently*** better with Carpenter Stainless Steels for specialists

The Carpenter Steel Company, Main Office and Mills, Reading, Pa.
Export Dept., Port Washington, N.Y.—"CARSTEELCO"
Alloy Tube Division, Union, N.J.
Webb Wire Division, North Brunswick, N.J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.



Complexity of ITT's far-flung manufacturing activities demands adequate means of analyzing investment opportunities

The management problems, including equipment replacement, of most large industries are multiplied many times over in the complex and far-flung manufacturing activities of the International Telephone and Telegraph Corporation. Yet, many of these problems are similar, and they respond to the same treatment regardless of company size, plant location, or product involved.

In the following statement, Mr. Harry G. Beggs, Vice-President and Director of Manufacturing and Facilities, points out the necessity of a proper method of analyzing investment opportunities in his corporation and recommends to all industries that the establishment of such a procedure be given high priority.

HARRY G. BEGGS, *Vice-President*
Director of Manufacturing and Facilities

"We have recently established worldwide policies and procedures for the analysis of investment opportunities.

"The establishment of uniform policies and procedures in a company such as ours with 109 manufacturing plants in 20 countries throughout the world is an extremely complex and difficult task. However, due to this complexity and the added attention being paid to overseas manufacturing opportunities, the need for adequate means of analyzing investment opportunities is becoming more apparent.

"We have noticed an ever-increasing interest in the replacement of human effort by the use of machinery, on the part of our foreign Managing Directors. This has resulted from cost competition pressures and the need to offset labor shortages in many countries with economical mechanical means of production. This also has raised a critical parallel need for the utilization of the latest investment analysis techniques.

"In establishing policies and procedures for examining investment analyses, we have emphasized two major points.

"1. The rate of return on the investment in the new facilities is the most important factor in determining the most desirable investment to make.

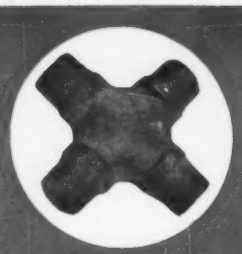
"2. We must concentrate first on adequately analyzing the economics related to each of the more desirable alternate investments to achieve the results desired. The selection of the most desirable alternates is the key to successful investment analysis.

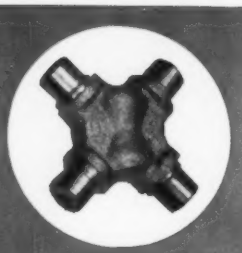
"It is our firm conviction that the techniques of making investment analyses are probably the least understood and most often neglected areas of business analysis. Most important, we feel that the making of adequate investment analyses and sound decisions based on such analyses has as much influence on the long range profit position of a company as any other single factor, except for the possible selection of outstanding personnel.

"Management in ITT intends to improve upon their present performance in analyzing alternate courses of action to meet company-wide objectives.

"We heartily recommend to all industrial companies the importance of an adequately established procedure for making continuing analyses of those investments in plant and equipment which will result in improved returns on the investment in the company."

HOW TO MACHINE Universal Joint Spiders AT LOWER COST

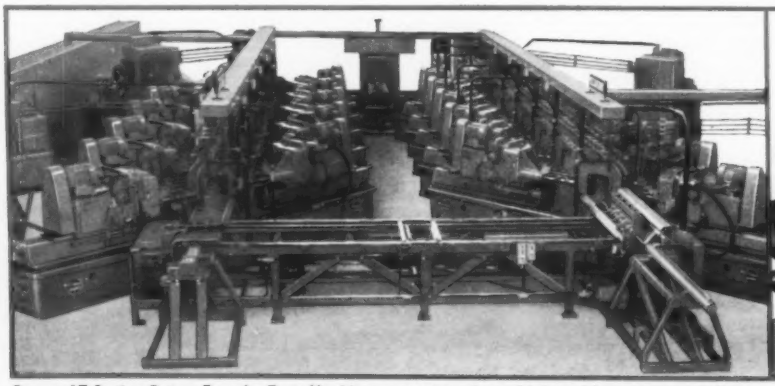




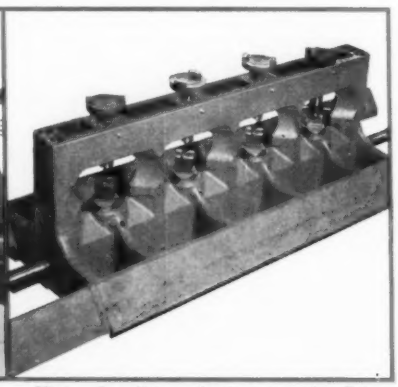
Positioning in Transfer Fixture Permits Straight-Through Operations, Conserves Space

Here is another example of how W. F. and John Barnes special machine engineering has effected a substantial reduction in production costs. By combining operations on two ends of four parts at each working station, universal joint spiders are drilled, chamfered, and hollow milled in a continuous cycle at a gross rate of 766 pieces per hour. Positioning and clamping of parts in pallet-type transfer fixtures permits straight-through operations without unclamping or re-positioning the workpieces. Rough broaching the forgings is the only preliminary operation.

A further refinement in the machine design includes power clamping of parts in fixture and automatic unclamping and unloading after machining operations are completed. Pallets are then returned to operator at the loading station. This same principle can be economically applied to a wide range of similar parts. Modifications in machine design can be made to suit individual production and cost requirements.



Barnes 17-Station Return Transfer-Type Machine processes universal joint spiders at gross production rate of 766 pieces per hour. Over-all floor space 2576 square feet.



View of pallet pusher-type transfer fixture equipped with clutch drive screws for automatic clamping and unclamping of 4 workpieces.

Builders of Better Machines Since 1872

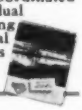
W. F. & JOHN BARNES

ASK FOR AN ANALYSIS OF YOUR PRODUCTION METHODS

For assistance with any production machining job we suggest you call in Barnes engineers and ask them to assist you. Your production problems will be closely analyzed and given expert attention. All design and engineering as well as manufacturing facilities are coordinated at Barnes to help you solve problems quickly and efficiently.

Write for Free Brochure

Describes Barnes complete 6-point coordinated machine tool building facilities. Individual bulletins are also available describing and illustrating a wide variety of special drilling, boring, and tapping machines as well as special automation equipment.



W. F. & JOHN BARNES COMPANY
402 SOUTH WATER STREET • ROCKFORD, ILLINOIS

Multiple Spindle Drilling • Boring • Tapping Machines • Automatic Progress Thru Transfer-Type Machines

August, 1961

For more data circle No. 846 on Readers' Service Card.

CENTER OF MACHINE-TOOL EXCELLENCE **ROCKFORD, ILLINOIS, U.S.A.**

IMPORTANT MESSAGE

to the Aircraft and Steel Producing Industries

☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆

Proved fast method of flat grinding

STAINLESS *and* TITANIUM SHEETS

HONEYCOMB

holding ± .001 inch with negligible burr

Aircraft fabricators have proved it. Conveyorized abrasive belt grinding is the **fastest, most economical method** of finishing wide honeycomb cores and stainless or titanium sheets to within ± .001 in.

Two types of rigid, wide-belt wet grinders are increasing production rates and setting a new standard of reliability in continuous, heavy-duty operation. Sandwich construction no longer is limited by sheet or honeycomb finishing operations.

The Mattison No. 458 conveyorized grinder is designed for fast, batch-type grinding of honeycomb cores. See if you don't find these features entirely logical for fast production grinding and high accuracy:

1. Four rolls in the diamond-shaped head continuously "flex" the long (20 ft, 3 in.) abrasive belt—keep it clean, cool, and free-cutting.
2. Separate contact and drive rolls prevent transfer of motor pulsations to the work.
3. Clockwise rotation of abrasive belt, **pulled through** the grind point under constant tension, assures positive grain penetration and high stock removal rates.
4. Table upfeed through six precision jacks maintains perfect parallelism in all directions.
5. Automatic table upfeed (increments from .0002 in. to .005 in.) is pushbutton actuated. Pushbuttons or handwheel to control rapid vertical traverse.

The No. 456 pinch-roll-feed wet grinder, with the same rigid head design and advantages, is used to:

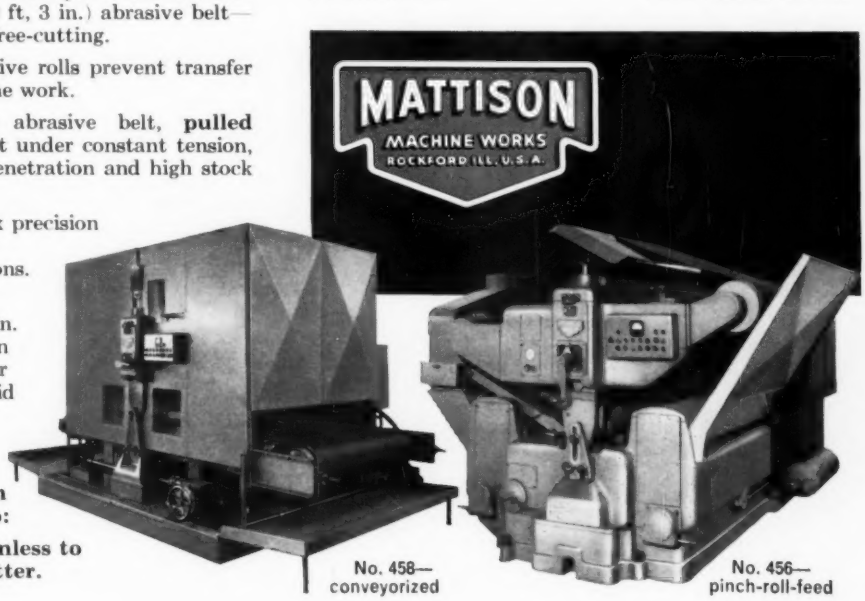
1. **Finish PH15-7Mo stainless to 32 microinches, or better.**
2. **Economically grind copper sheets used in sandwich brazing to uniform thickness.**

Stabilized air control on the billy roll makes grinding pressure constant throughout the length of the sheet and avoids taper grinding. Positive billy roll stops are manually controlled in increments of .001″ or finer.

Electronic billy roll actuation holds uniform grinding pressures within ¼ in. of lead and trailing ends—prevents sheet marking caused when sharp ends scrape an abrasive belt.

For a convincing demonstration in the Mattison Methods Lab, phone your Mattison dealer or write us.

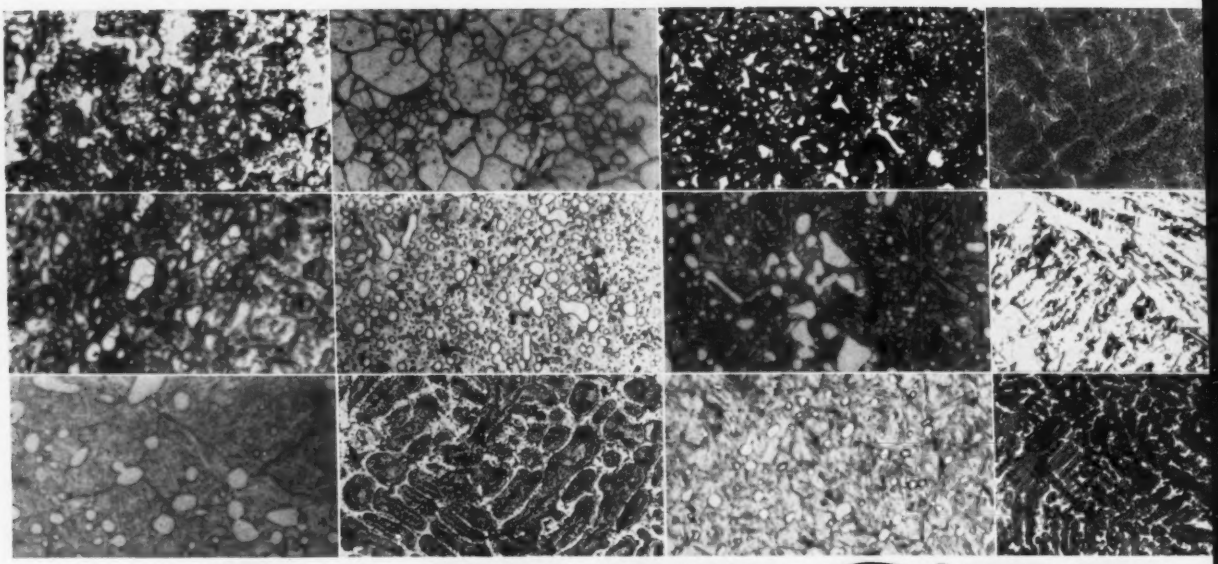
MATTISON MACHINE WORKS
Rockford, Illinois — Phone WOodland 2-5521



No. 458—conveyorized

No. 456—pinch-roll-feed

CITY OF MACHINE-TOOL SPECIALISTS **ROCKFORD, ILLINOIS, U.S.A.**



WHICH STEEL

■ It's a good idea to buy cutters from a company that knows

MAKES THE BEST CUTTER?

the answer to this question. These high-speed steels, only a few of those submitted to us each year by the mills, were rejected in our metallurgical department. None of them has the right combination of red-hardness properties, toughness, wear-resistance, hardenability, and stability under heat treatment. Every Barber-Colman cutter, no matter what the size or price, is made from mill-selected tool steels which meet our own metallurgical standards. Every cutter starts in our shop with a complete metallurgical check – not only to determine correctness of ma-

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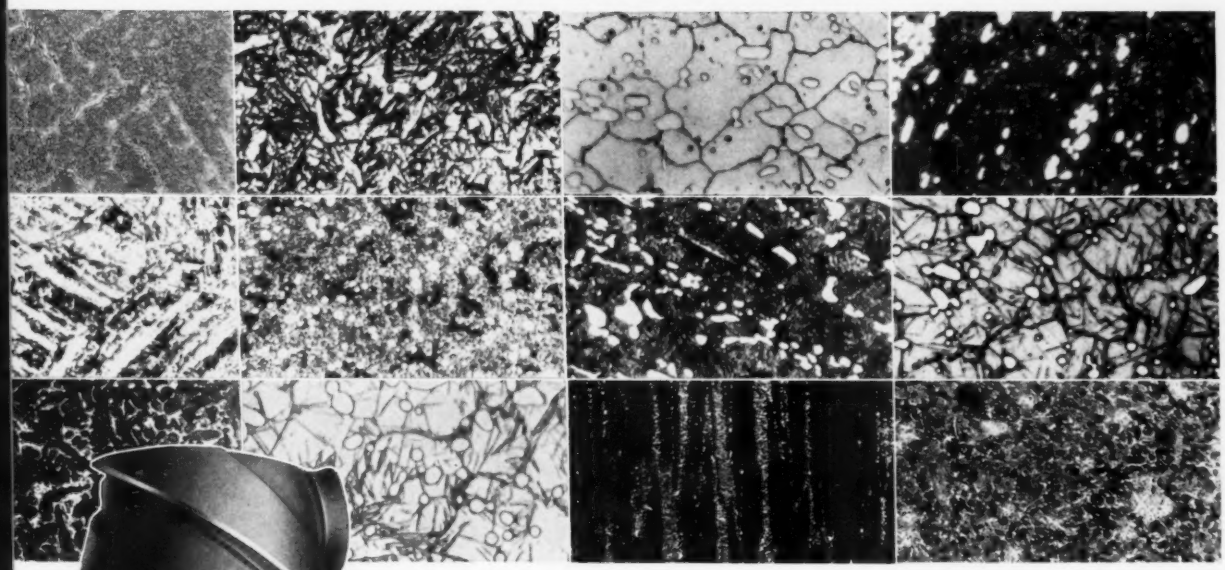
CENTER OF MACHINE-TOOL EXCELLENCE **ROCKFORD, ILLINOIS, U.S.A.**



terial, but also to provide data to be used by our engineers and toolmakers in producing the finest possible tools from that material. ■ Look-alike cutters can be miles apart in quality. Your best test is total COST-PER-PIECE, and your best bet is Barber-Colman quality. (Complete range of standard cutters for off-the-shelf delivery.) Ask your Barber-Colman representative for a copy of the hard-cover MILLING CUTTER HANDBOOK – 219 pages of useful information on selection, use, and care of milling cutters. NOTE: Your special cutters receive individual material analysis, selection, and heat treatment if you specify type and hardness of metal to be machined.

BARBER COLMAN

BARBER-COLMAN COMPANY 82 LOOMIS STREET, ROCKFORD, ILLINOIS

For more data circle No. 848 on Readers' Service Card. August, 1961

FOR PRODUCTION MACHINE TOOLS IT'S **ROCKFORD, ILLINOIS, U.S.A.**

how to improve your turning methods with SUNDSTRAND *"ENGINEERED PRODUCTION"*

The Sundstrand "Engineered Production" approach to your turning requirements guarantees you maximum productivity per dollar of machine investment.

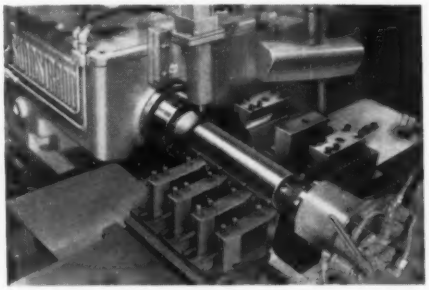
Sundstrand engineers first evaluate your production requirements, then provide the machine and tooling that give you the most economical production possible. Initial investment, present and future work requirements, workhandling, floor-to-floor time, tooling requirements, and other factors all are taken into full consideration to assure you lowest possible cost per piecepart.

Often a standard Sundstrand automatic or tracer lathe is the best machine for the job. Or the greatest production efficiency may be secured by adding special tooling, automatic loading, special cycling controls, or other accessories to standard machines. Where production warrants, completely special machines may be the most economical answer.

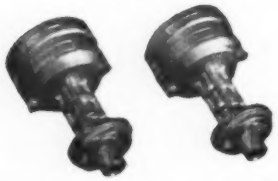
To discover the opportunities for more production profits in your shop, ask us about a Sundstrand "Engineered Production" analysis of your turning operations.

1 SMALL-LOT TURNING

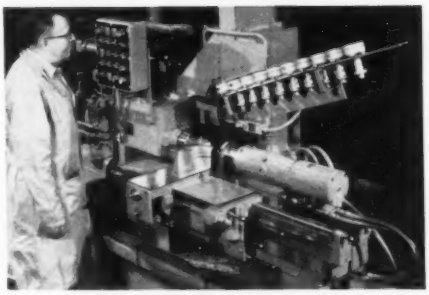
Production increased from 30 to 106 pieces per hour — in turning one of various plungers and liners when the job was put on this Model 8A lathe. Comparable savings were realized on the 12 different sizes of parts machined on this lathe. Simplicity of set-up makes Sundstrand multi-tool lathes practical for small lot sizes.



2 LONG-RUN TURNING

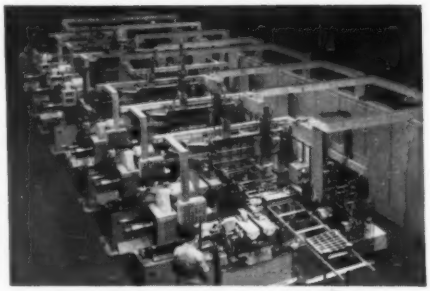


These die-cast aluminum housings are produced at a rate of 420 pieces per hour on this Sundstrand automatic lathe. Operations include turning the locating diameter and facing the flange. This standard machine has a completely automatic cycle that includes part-loading from a hopper and ejection of the finished workpiece.



3 SPECIAL TURNING

Sundstrand experience can make a big difference, both in initial investment and machining cost per piece, when large volume production dictates the use of special turning equipment. Here in continuous automatic cycles, camshafts are loaded, unloaded and transferred through this 8-lathe line at more than 200 parts per hour.



SUNDSTRAND

SUNDSTRAND MACHINE TOOL

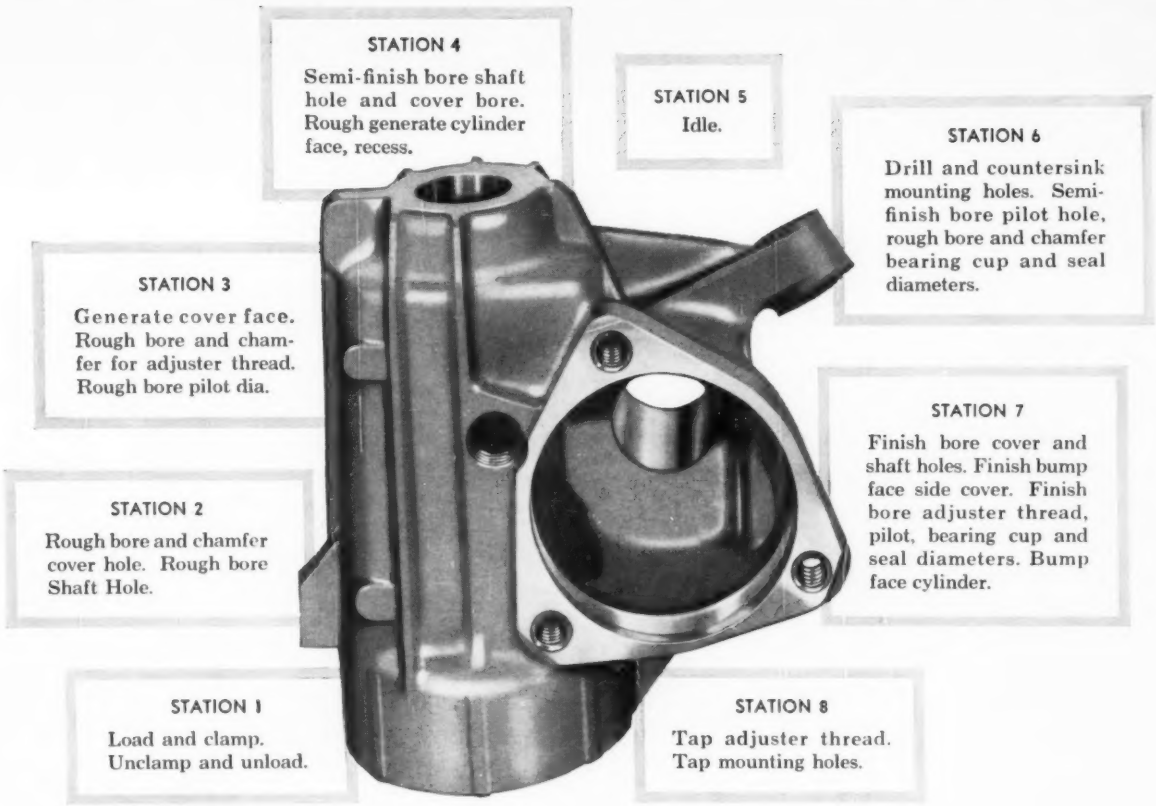
BELVIDERE, ILLINOIS

Division of SUNDSTRAND CORPORATION

Get the facts on how improved machines and methods based on Sundstrand "Engineered Production" evaluations can reduce your turning costs. Write today for Bulletin 630-1.

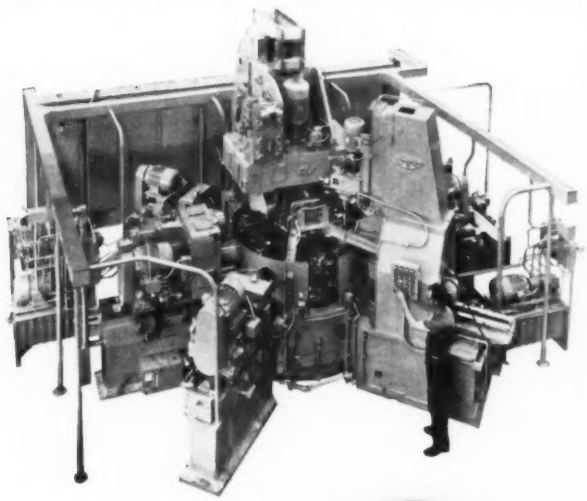
For more data circle No. 849 on Readers' Service Card.

MACHINES DESIGNED TO MEET YOUR NEEDS **ROCKFORD, ILLINOIS, U.S.A.**


STATION 4
Semi-finish bore shaft hole and cover bore. Rough generate cylinder face, recess.
STATION 5
Idle.
STATION 6
Drill and countersink mounting holes. Semi-finish bore pilot hole, rough bore and chamfer bearing cup and seal diameters.
STATION 3
Generate cover face. Rough bore and chamfer for adjuster thread. Rough bore pilot dia.
STATION 7
Finish bore cover and shaft holes. Finish bump face side cover. Finish bore adjuster thread, pilot, bearing cup and seal diameters. Bump face cylinder.
STATION 2
Rough bore and chamfer cover hole. Rough bore Shaft Hole.
STATION 1
Load and clamp. Unclamp and unload.
STATION 8
Tap adjuster thread. Tap mounting holes.

153 Aluminum Steering Gear Housings per hour

automatically processed on this GREENLEE Machine



This Greenlee 8-Station Horizontal and Vertical Spindle Machine is establishing some excellent performance records for a leading automotive manufacturer. The 52 inch table carries 8 work fixtures. Each has power clamping. To insure rigidity and accuracy, the table is clamped hydraulically metal to metal. Indexing is fully automatic. Cycle time is 23.5 seconds. Like all Greenlee machines it's built for long, continuous service. Can be modified economically if desired. Have our representative give you complete information.

MACHINES DESIGNED
WITH THE FUTURE IN MIND

PRODUCTION MACHINERY

GREENLEE BROS. & CO.

Since 1862 — 1978 Mason Avenue, ROCKFORD, ILL.

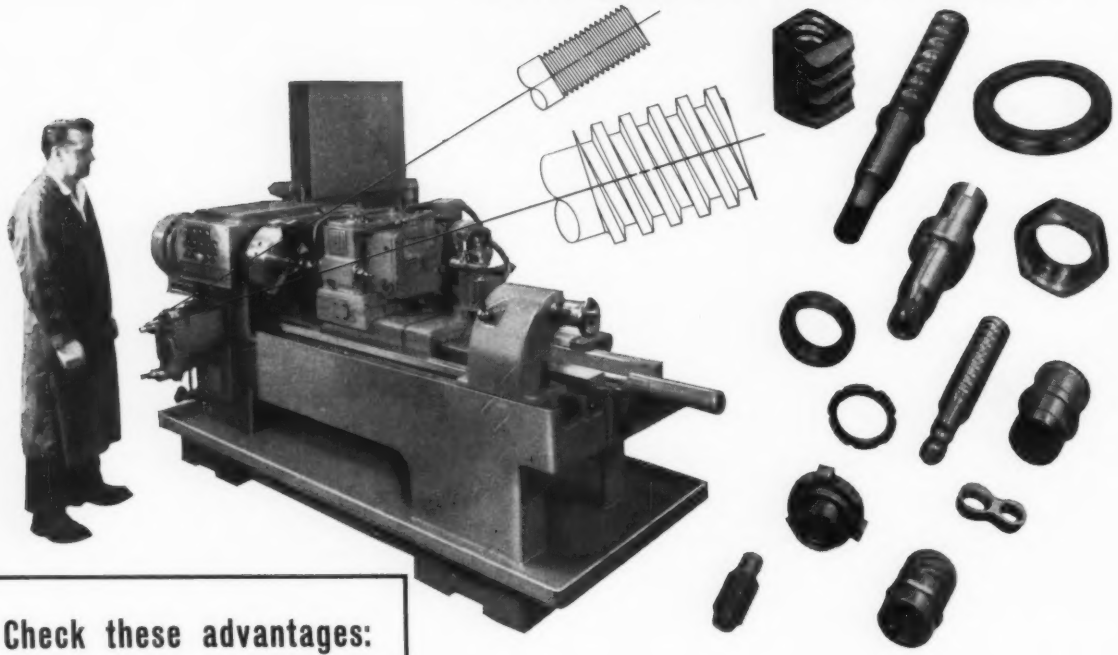
TRANSFER MACHINES • SPECIAL MACHINES • AUTOMATIC BAR MACHINES • WOODWORKING MACHINES AND TOOLS
DIE CASTING MACHINES • TRIM PRESSES • HYDRAULIC AND HAND TOOLS • COMMERCIAL CASTINGS

For more data circle No. 850 on Readers' Service Card.

August, 1961

FOR PRODUCTION MACHINE TOOLS IT'S **ROCKFORD, ILLINOIS, U.S.A.**

SUNDSTRAND thread milling machine improves quality and reduces costs on parts like these



Check these advantages:

- Mills internal or external threads . . . right- or left-hand . . . straight, tapered, or special . . . on straight or interrupted work surfaces, such as splines, keyslots, and flutes
- Makes external threads one pitch away from a shoulder, internal threads one pitch from bottom of a blind hole
- Accurately relates pitch diameters to other elements of the workpiece
- Mills threaded and plain diameters simultaneously
- Simultaneously mills two threads of the same pitch and lead on the same or different diameters
- Threads workpieces of various diameters with a single cutter

. . . features sine bar adjustment for threads up to 1/2" lead, fully automatic cycling, and 5-minute change-over

Here's an automatic thread milling machine that provides high production and precision accuracy on a wide range of threading operations, including those difficult, costly, or impractical by other methods.

The machine uses multiple thread cutters with the desired pitch and thread form but without lead. An exclusive dial-adjustable sine bar mechanism provides an infinite range of thread leads from 0 to ½".

Because there are no gears or cams to change for different thread leads, change-over is simplified. Fast, five-minute setup makes the machine ideal for short or long runs on a variety of parts.

Once the setup is made, machining cycle is completely automatic. This feature, plus inherent machine accuracy and simplicity of adjustment, eliminates the need for special operator skills. High-quality, consistently uniform threads are readily produced to the exacting requirements of military and aircraft specifications.

Four models handle workpiece lengths up to 24", 48", 72", and 96". A wide selection of optional attachments is available to speed production and increase the versatility of these machines.

SUNDSTRAND

SUNDSTRAND MACHINE TOOL
BELVIDERE, ILLINOIS
Division of SUNDSTRAND CORPORATION

The machines to improve your threading operations are described in a new Sundstrand Bulletin No. 630-2. Write for a copy today.

August, 1961

For more data circle No. 851 on Readers' Service Card.

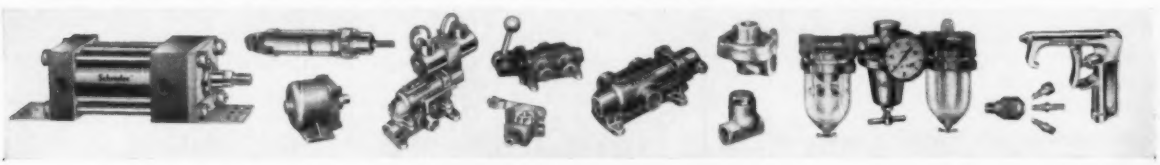
MACHINES DESIGNED TO MEET YOUR NEEDS **ROCKFORD, ILLINOIS, U.S.A.**

There's a quality difference in any Schrader Air or Fluid Product

EXAMPLE: Schrader Square-end Cylinders not only have quality built into every part, but feature many extras. For instance, the unique cartridge-type bronze bearing assembly (A) is easily removed by releasing just one retaining ring—no need to dismantle the entire cylinder for bearing maintenance. Special "step" design cylinder seal (B) assures perfect alignment and positive seal without danger of gasket damage. Below surface cushion adjusting screws (C) are protected from damage but fully accessible. They lock to eliminate loosening due to vibration.

Interchangeable with all JIC cylinders, Schrader also provides a variety of mountings. Special bushings are available for bone-dry piston rod in hydraulic operation.

ANOTHER EXAMPLE: Schrader's new direct action Hydraulic Gauges without mechanical linkage (A) eliminate fatigue failure of internal parts. They can withstand 100% overload without damage to accuracy, and are triple-damped (B) to eliminate indicator oscillation from pump pulses, surges, or shock that would damage other types. Can be maintained and calibrated easily in the field. PSI pressure ranges 0-500, -1500, -3000, and -5000.



FULL LINES OF QUALITY AIR CIRCUIT COMPONENTS • OFF-THE-SHELF SERVICE AND INFORMATION FROM YOUR NEARBY DISTRIBUTOR • STAFFED WITH AIR CIRCUIT EXPERTS • CONSULT YELLOW PAGES OR WRITE FOR HIS ADDRESS

Schrader®
a division of **SCOVILL**

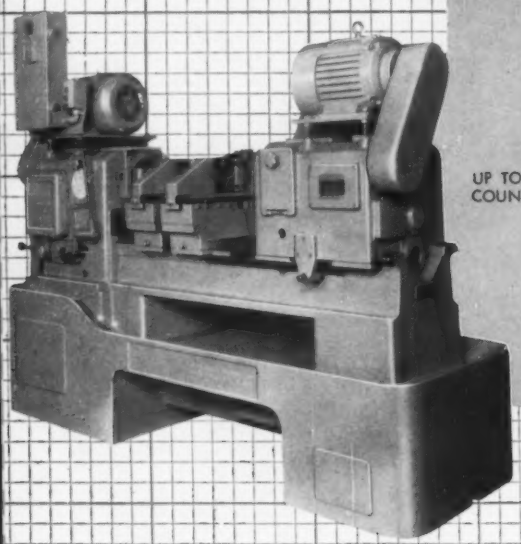
A. SCHRADER'S SON
Division of Scovill Manufacturing Co., Inc.
454 Vanderbilt Ave., Brooklyn 38, N. Y.

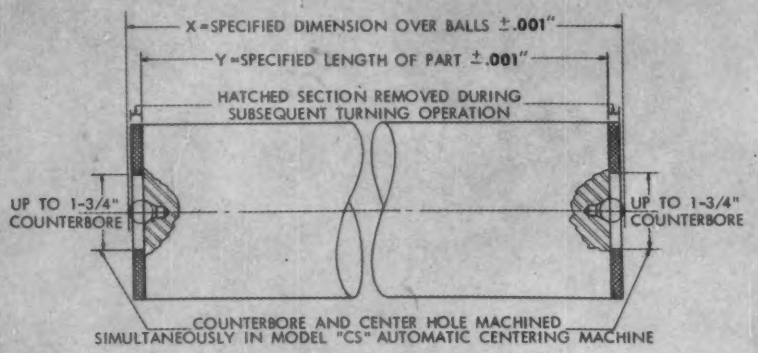
QUALITY AIR CONTROL PRODUCTS

For more data, circle this page number on Readers' Service Card.

SENECA FALLS MACHINE
ENGINEERED FOR PROFIT

IS INACCURATE CENTERING CUTTING YOUR PROFIT?




X = SPECIFIED DIMENSION OVER BALLS ±.001"
Y = SPECIFIED LENGTH OF PART ±.001"
HATCHED SECTION REMOVED DURING SUBSEQUENT TURNING OPERATION
UP TO 1-3/4" COUNTERBORE
UP TO 1-3/4" COUNTERBORE
COUNTERBORE AND CENTER HOLE MACHINED SIMULTANEOUSLY IN MODEL "CS" AUTOMATIC CENTERING MACHINE

BUILT-IN FEATURES OF MODEL "CS" AUTOMATIC CENTERING MACHINE

- Positive control of center depth to ±.001".
- Accurate location of the work piece to assure correct center depth at both ends.
- Correct angle and perfect alignment of center holes.
- Double action feed cam to produce a smooth cleanly finished center hole.
- Quick change-over through pre-set graduated cams.
- Complete automatic cycle, 100% mechanical.
- Automatic work handling equipment available.

Accurate centering of work to be turned or ground is a most critical first operation. Inaccurate centering piles up unnecessary costs in terms of rework time, rejects and inferior product quality.

A Seneca Falls Model "CS" Automatic Centering Machine equipped for simultaneous spot facing and centering not only guarantees perfect centering on a production basis but eliminates the need for purchasing expensive centering and milling equipment.

Model "CS" is a positive action, cam fed machine equipped with properly designed spot facing cutters. No longer will you need costly spring centers and endwise locators for subsequent turning operations.

Obtain the performance diagrammed above on a continuous high production basis. The crosshatched area will be removed during the turning operation where optimum horsepower is available.

Send some of your sample parts today. Let us spot face and center them as a demonstration of what this machine will do for you.

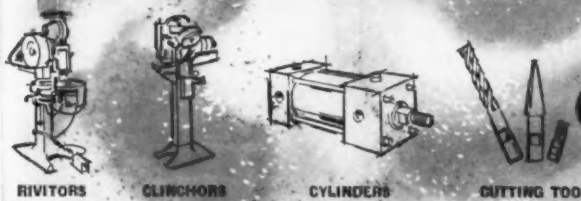
Write for Bulletin CS-60

SENECA FALLS MACHINE
ENGINEERED FOR PROFIT

SENECA FALLS MACHINE CO., SENECA FALLS, N. Y.

BIG NEWS

The T-J Spacemaker cylinder line is not now, nor ever has been, a probe into outer space. It is offered as a practically designed, research engineered and time tested product. Its Spacemaker feature (no tie-rods) and rugged construction gives greater strength, saves space and reduces costs in all power drive applications. The Spacemaker is available in a complete range of bore sizes and strokes, air or hydraulic, and contains many *plus features* and extras as STANDARD . . . NO EXTRA COST! Write Tomkins-Johnson, 2425 W. Michigan Ave., Jackson, Mich. for Bulletin #155-4 and for full particulars, today.



T-J TOMKINS-JOHNSON
JACKSON, MICHIGAN

For more data, circle this page number on Readers' Service Card.

UNBREAKABLE!

This is a punishing test for a hack saw blade. We do it to prove that a Marvel High-Speed-Edge Hack Saw Blade is unbreakable. A Marvel Blade can be bent like this thousands of times and it still won't break.

Why? Because the blade body—to which a high speed steel cutting edge is welded—is made of a tough, non-brittle alloy steel designed to take the heaviest feed pressures and highest speeds any modern hack sawing machine can develop.

What does this unbreakable feature of Marvel Blades mean to you?

1. Operators, knowing they can trust Marvel Blades not to break, tension them truly taut (from 200% to 300% more than ordinary blades) to produce maximum obtainable accuracy of saw cut.
2. They can safely apply heavier feed pressures and higher speeds without endangering themselves or the machine to produce faster cutting-off.
3. Longer cutting life is assured because the blade simply won't break.

Ask for Marvel High-Speed-Edge Hack Saw Blades by name and you can be sure you're getting the unbreakable blades designed to give you maximum accuracy, speed, and safety in your cutting-off operations. Leading Industrial Distributors have Marvel Blades in stock.

MARVEL *Metal Cutting* **SAWS**

BETTER MACHINES
BETTER BLADES

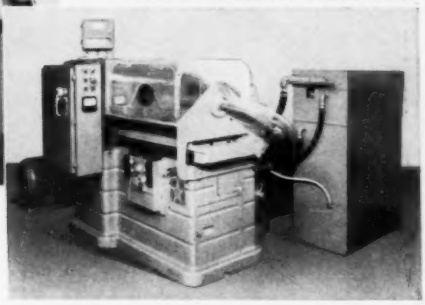
ARMSTRONG-BLUM MANUFACTURING CO. • 5700 Bloomingdale Avenue • Chicago 39, Illinois

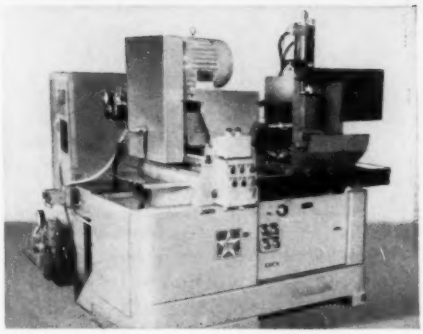
B-1128

Star "REBUILT" EQUIPMENT GIVES YOU LOW-COST HOLE FINISHING—FROM SOLID, CORED OR PRE-DRILLED HOLE TO PRECISION SIZE AND FINISH—

in one operation!

USING Starbore DRILLS, GUN DRILLS AND PRESSURE COOLANT REAMERS.





Shown here are a few examples of Star "rebuilts", with Star-bore tooling, that are making money for their owners.

Star's master machinists will rebuild your present equipment, (or a modern Machine from our stock), to your specification, and with a NEW MACHINE GUARANTEE!

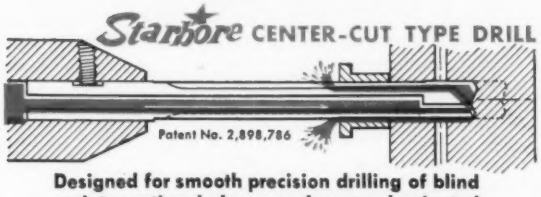
You too can save equipment outlay, improve your competitive position and boost your profits with equipment rebuilt by Star, the precision hole drilling and reaming specialists.

Let us give you an estimate!

Starbore tooling gives you—

- ★ **LONGER TOOL LIFE**
- ★ **REDUCED NUMBER OF OPERATIONS**
- ★ **CLOSER TOLERANCE**
- ★ **IMPROVED FINISH**

Starbore CENTER-CUT TYPE DRILL



Designed for smooth precision drilling of blind or intersecting holes, cored areas, laminated sections or recesses. Off-center pressurized coolant port produces no pin.

Starbore TWO-FLUTE, MULTI-DIAMETER REAMER

In many cases these high precision tools can ream a die cast or rough-cored hole to a highly accurate, finished, stepped hole in one operation. Note ample purging action of pressurized coolant.

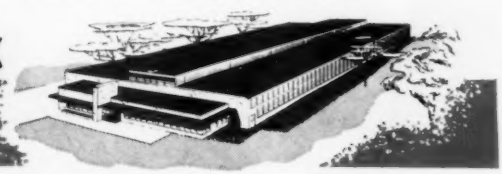
Write for detailed literature on Starbore gun drilling tools.

Star Cutter Company

Originators of Automatic Universal Face Tools

24500 GRAND RIVER AVE., FARMINGTON, MICHIGAN

Telephone: (Detroit), KEnwood 2-4500



For more data, circle this page number on Readers' Service Card

LOCTITE GIVES YOU

THE IMPOSSIBLE PERFECT FIT

Only a small percentage of the adjacent metal surfaces of a press or interference fit are actually in contact. Yet the security of the entire assembly depends on that small area of contact.

Rigid tolerances are specified, and extra machining operations are performed to increase the area of contact. Nevertheless, it has been impossible to mate two metal surfaces perfectly, one inside the other. The Perfect Fit, like Infinity and Perpetual Motion, has seemed to exist only in theory.

YET A FEW DROPS OF LOCTITE CAN NOW PROVIDE WHAT THE MOST EXPENSIVE OF MACHINING METHODS CANNOT.

LOCTITE Sealant is a penetrating liquid resin that by capillary action is drawn into all the voids in a press or interference fit, filling them completely. Once there, LOCTITE hardens automatically into a tough, solid, load-bearing plastic film, capable of supporting loads in excess of 25,000 pounds per square inch, thus providing *A PERFECT FIT* of adjacent surfaces.

FACTS ABOUT LOCTITE SEALANT:

- LOCTITE is easy to use. It requires no mixing or heating.
- LOCTITE is 100% active. It totally fills the voids in press fits and threaded assemblies.
- LOCTITE contains no solvents—requires no solvents. There is no hardening shrinkage due to solvent evaporation.
- LOCTITE requires no expensive equipment. The bottle is the applicator; or mass application procedures can easily be set up with "around-the-shop" parts and materials.
- LOCTITE will withstand temperatures up to 300°F.

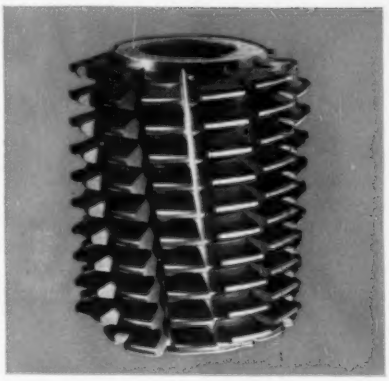
LOCTITE Sealant makes a slip fit as strong as a press fit, a press fit stronger. It can be used to relax tolerances and to improve reliability.

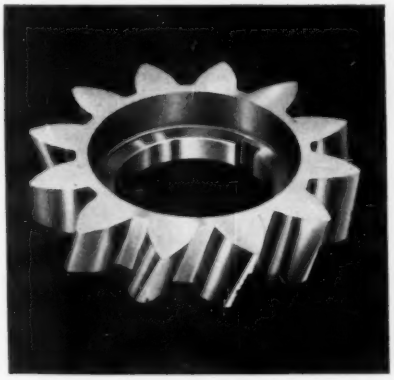
Wherever metals are LOCKED—RETAINED—SEALED there is an opportunity to cut costs and increase profits with LOCTITE. Details on your application bring immediate response from our Application Engineering Department. Write today.

LOCTITE® SEALANT

AMERICAN SEALANTS COMPANY
207 North Mountain Road • Hartford 11, Connecticut

the more gears you cut, the greater your need for job-tailored Illinite® hobs and shaper cutters!





Increased costs and capacities of modern mass-production machines impose performance responsibilities which all-purpose tools were never intended to meet. That's why more and more volume gear-makers are protecting their capital investments with *job-tailored* Illinite hobs and shaper cutters.

Whether mass-produced gears are standards or specials, you'll get better work at lower costs with designed-for-you Illinite gear cutting tools – the specific-purpose hobs and shaper cutters that turn out consistent, economical accuracy. ***They're developed and made to do one job best—and this means long life, top output, low rejects.***

For nearly 50 years, Illinois Tool Works has helped gear makers solve troublesome problems through improved gear geometry, superior metallurgy, and precise inspections for accuracy. Experienced ITW field engineers will be glad to study your production facilities as well as end-use requirements, and submit cost-cutting recommendations.

ILLINOIS TOOL WORKS
TOOL & INSTRUMENT DIVISION
2501 N. KEELER AVENUE • CHICAGO 39, ILLINOIS

Write for these two informative handbooks, "Faster Gear Production" and "Know Your Shaper Cutters" —two "musts" for your technical library. Do it now before you forget.

For more data, circle this page number on Readers' Service Card.

No. 7373 Feed roll idler on card processing business machine. Full size, as shown.

No. 6889-2 Guide roller on card processing business machine. Approximately 1½ size.

NICE "specials" provide the Product Designer with exceptional opportunities for cost reduction and product improvement. The properly designed "special" not only performs its basic bearing function, but may incorporate features that simplify mounting or installation, or combine several components into a single interchangeable "package" unit.

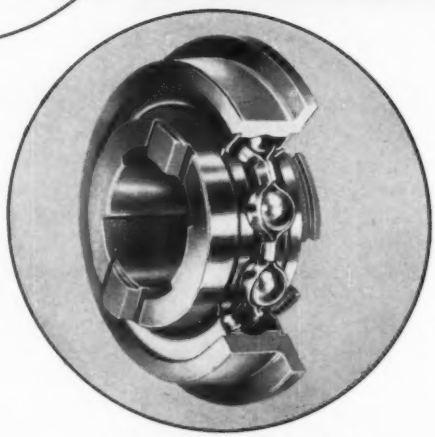
Almost six decades of bearing experience have given NICE an unusual background of experience in the field of "specials". Hence, NICE engineers are well qualified to design bearings that will fulfill particular application requirements . . . economically and efficiently.

Can NICE help you?

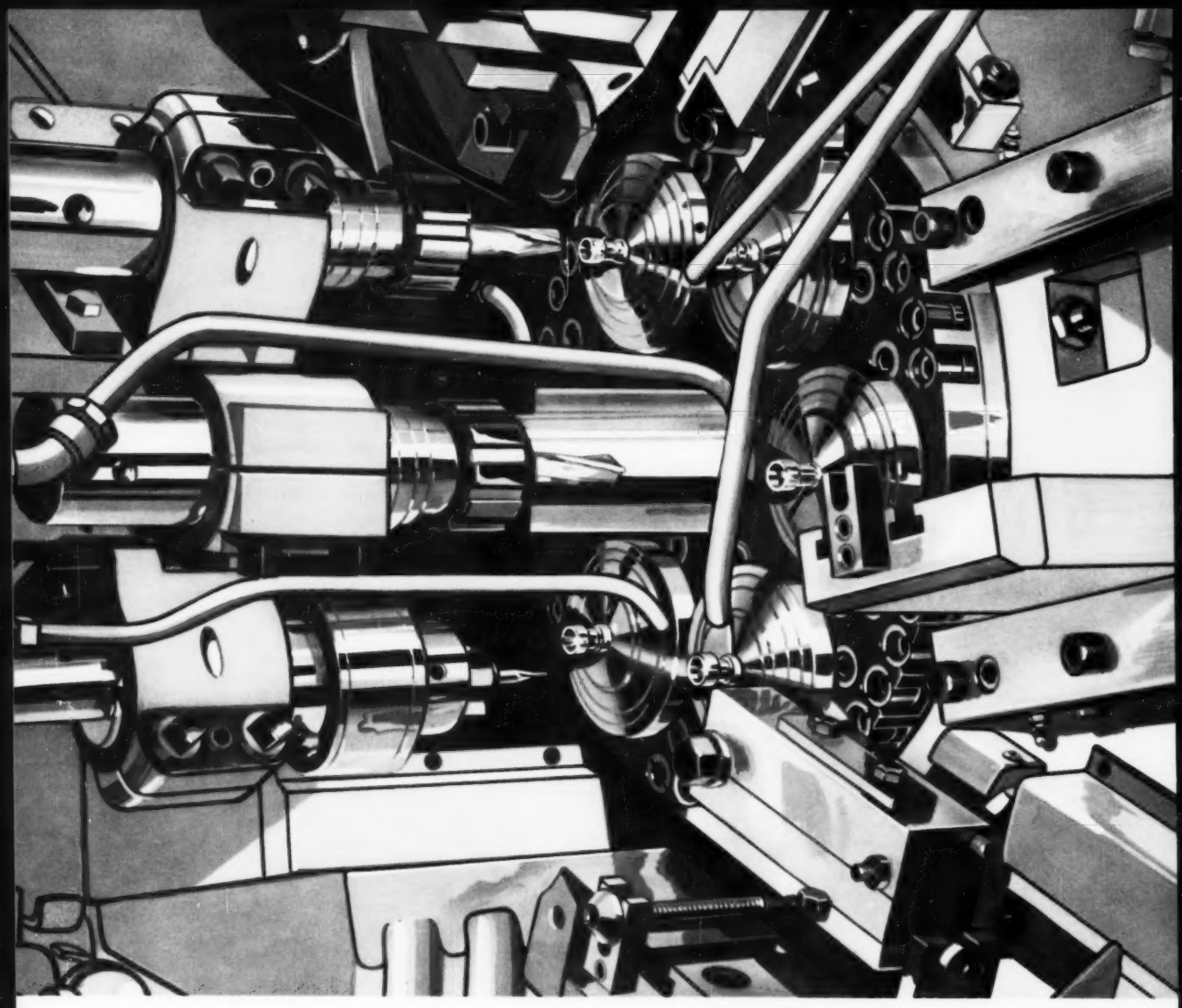
NICE

NICE BALL BEARING CO.

NICETOWN • PHILADELPHIA • PENNSYLVANIA



No. 7233-2 Pulley bearing in clutch assembly of automatic washer. Approximately full size.



The newest bar machines *are New Britains*

How much work can you wring out of a bar machine? It depends on the machine, how it's tooled and who's using it. New Britain's New-Series Bar Machines are setting some pretty enviable productivity records right now. These machines, redesigned from the ground up, are the most advanced units of their kind available to the metalworking industry.

The four-spindle machines have capacity up to 5⅛″ and all the massiveness and power needed to turn work of this size.

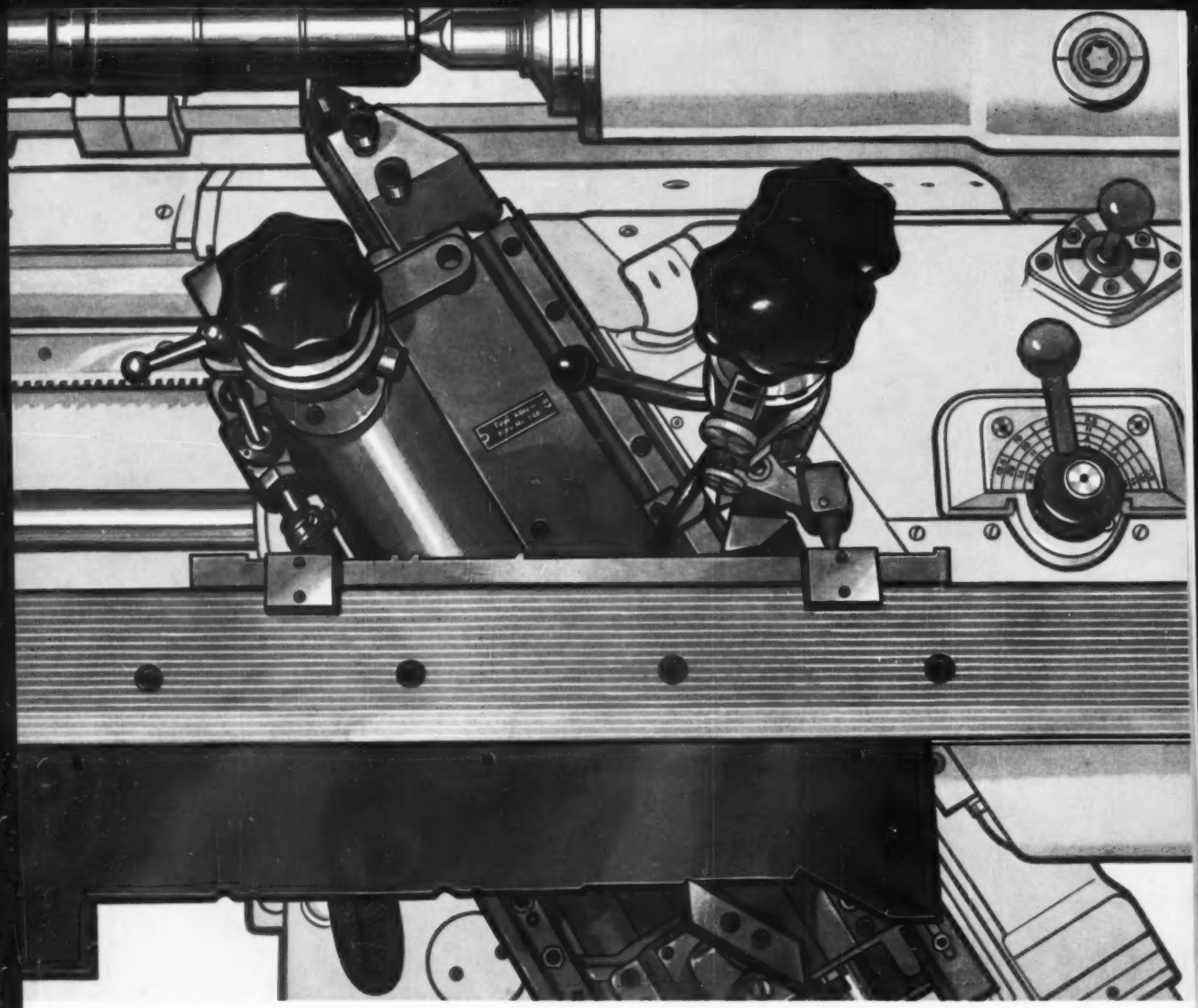
New series six-spindle machines in various models have capacities ranging up to 3½″. The eight-spindle machines take work to 2⅝″ capacity.

Increased capacity is only part of the story. Tooling combinations are practically limitless. With end-working and cross slide tooling in every position on every model, the greatest possible variety of operations can be performed to the highest order of accuracy. Numerous familiar New Britain features, like spindle carrier lifting and locating, have been retained and improved. A great many exclusive new features have been added.

Why not send for our new catalogs which give the whole story in detail or call your New Britain representative to arrange a demonstration?

THE NEW BRITAIN MACHINE COMPANY

New Britain-Gridley Machine Division ◆ New Britain, Connecticut



Fast set-up, quick changeover *with New Britain +GF+ copying lathes*

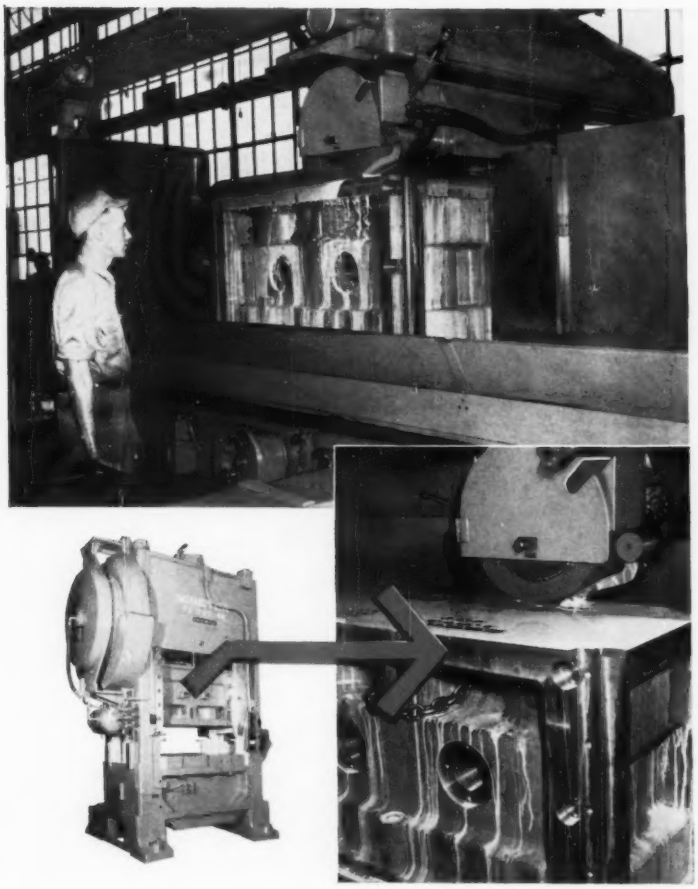
The basic design of a New Britain **+GF+** copying lathe can start to save you money on the first job you put on it. Because the single tool is guided by either a prototype or a template, set-up time is reduced to minutes. The single tool can be changed in minutes, too. Every dimension is positively transmitted from template or prototype to the work, making adjustment a simple matter of bringing only one dimension to size. A **+GF+** does a great variety of work—shafts, chucking work, internal *and* external copy turning. Backfacing is accomplished by a simple attachment. Multi-cut recycling for the removal of heavy stock concentration can also be provided.

The versatility of application is pretty much limited only by the ingenuity of the individual. For more complicated jobs, New Britain can provide the most complete selection of steadies, special tooling attachments and other accessories available for any lathe anywhere. A complete range of models and sizes is available. Why not write for our new **+GF+** copying lathe catalog?

THE NEW BRITAIN MACHINE COMPANY
New Britain-Gridley Machine Division • New Britain, Connecticut

SIZE FOR SIZE

there are no heavier or more accurate surface grinders made than these fast, heavy duty Thompsons



Thompson Type CX heavy-duty surface grinders are designed to grind heavy, massive work pieces. Their stock removal rate is very fast while maintaining extremely close limits of accuracy and microfinish.

Shown here is a Thompson Type CX 30x36x96 machine recently installed in the Minster Machine Company plant at Minster, Ohio. It is grinding the face of the slide for a 200-ton capacity Minster Piece-Maker High Speed Automatic Production press.

The slide is cast iron and weighs approximately 7000 pounds. It is being ground for precise parallelism and to a 20 to 30 RMS finish.

Thompson Grinders have an important part in the production of these world-famous Minster presses. The dependability of Thompson Service and the excellent performance of the Thompson machines now in use at Minster were major factors in the purchase of this latest grinder.

If your production involves the grinding of large, heavy work, it will pay you well to investigate the money and timesaving features of these modern machines.

THE THOMPSON GRINDER CO. Springfield, Ohio

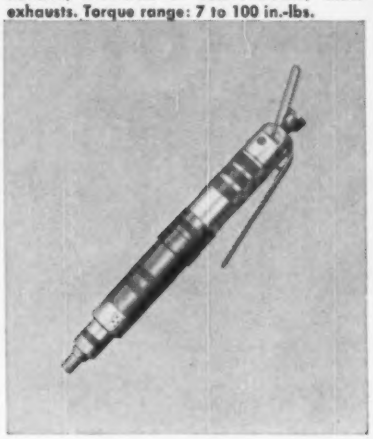
Thompson SURFACE GRINDERS

"Keep Thompson in mind for that daily grind"

For more data, circle this page number on Readers' Service Card.

NEW "DIAL TORK" Nutrunner. The only power tool you can "dial in" for the precise torque you want. Ideal for the type of assembly or service work where a variety of fasteners must be tightened to different torque settings—with hand torque accuracy.

"One-Shot" Air Screwdrivers with offset or lever handles; reversible or non-reversible; silent exhausts. Torque range: 7 to 100 in.-lbs.



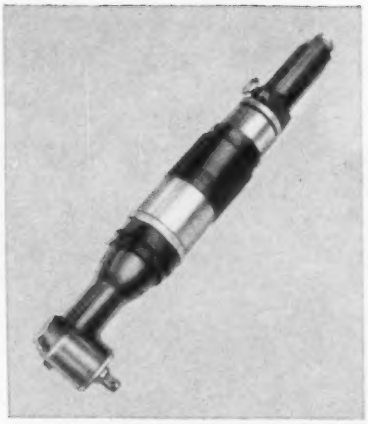
✻ The secret of CP "One-Shot" Fastener Driving Tools lies in the precise torque sensing ability of the tools themselves. Put the tool on the work—press the throttle—the instant precise torque is attained *all* driving action stops. Its torque-awareness is unequalled by *any* clutch for *accuracy* and *consistency*. So don't just specify "torque control"... be *sure* you specify CP "One-Shot."

CP "One-Shot" Screwdrivers can save up to 75% in fastener driving time... eliminate stripped threads.

Chicago Pneumatic

PNEUMATIC TOOLS • ELECTRIC TOOLS • AIR COMPRESSORS • DIESEL ENGINES • HYDRAULIC TOOLS • AVIATION ACCESSORIES

"One-Shot" Electric Screwdrivers with lever or offset handles. Torque range: 7 to 100 in.-lbs.



"One-Shot" Angle Nutrunners are jolt-free... easy to hold! Fasteners installed accurately to torque specifications. Range: ½ to 200 ft.-lbs.

CP-200 Torque Analyzer provides fast, simple method for checking clutch settings and stall torques of portable tools. Maximum capacity: 200 in.-lbs.

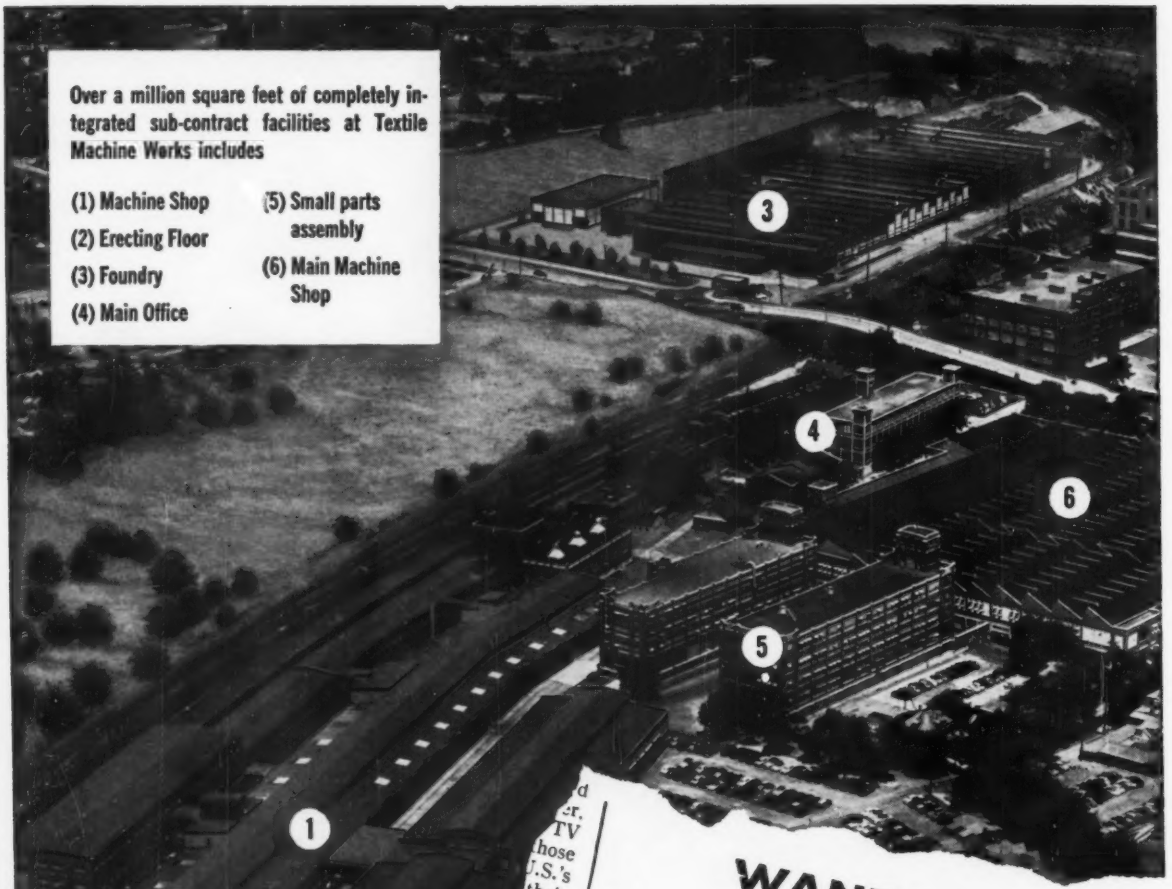
If your responsibility is threaded fastener driving... DON'T JUST SPECIFY "TORQUE CONTROL" ...SPECIFY CP "ONE-SHOT"* FOR THE ULTIMATE IN TORQUE ACCURACY, CONSISTENCY!

Since the first CP "One-Shot" torque control power screwdriver was introduced in 1954, industry has come to realize the *real plus values* of the consistent accuracy these tools maintain. They have proved their money-saving advantages because:

1. They cut spoilage and rejects to a minimum.
2. "One-shot" principle reduces clutch wear to the minimum... torque settings remain constant indefinitely... but are readily adjustable over a wide range when job specifications demand it.
3. They make training of operators easier and faster... simplify changes in work assignments.

CP manufactures the most extensive line of "one-shot" tools available today. Let a CP Torque Control Specialist help you solve your fastener driving problems. *Chicago Pneumatic Tool Company, 8 East 44th Street, New York 17, N.Y.*

"One-Shot" Nutrunners hold their settings... simplify training of operators.



WANTED

(by one of the largest, most modern and completely integrated manufacturers in the U.S.)

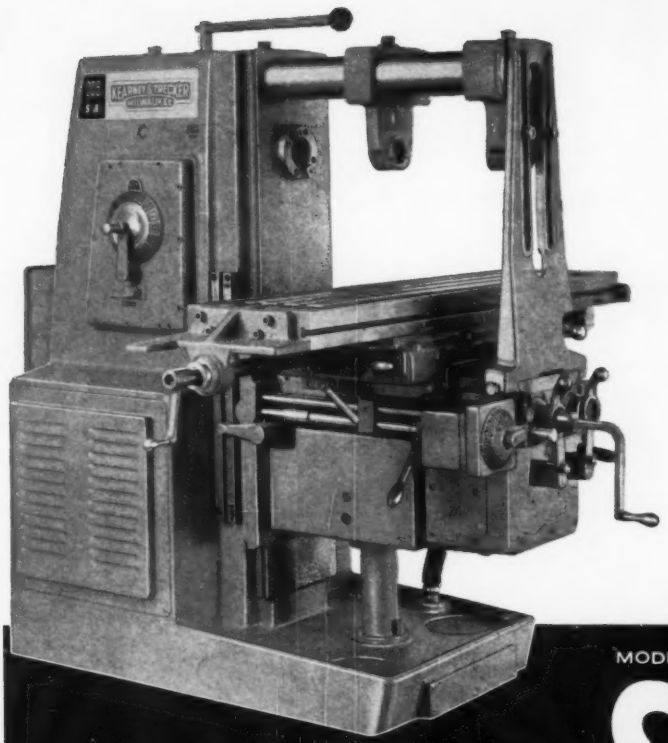
Production machining on a job or long-term basis; contracts for precision components, assemblies and complete machine building.

QUALIFICATIONS: 65 years' experience in precision (tolerance to 10ths) manufacturing, 1200 modern machine tools, a completely mechanized foundry (one of the country's largest), 3000 skilled craftsmen including a corps of industry's top designers and engineers.

REFERENCES: The best . . . companies like Alcoa, Du Pont, Chrysler, Eastman Kodak, Western Electric, Fairchild Aircraft, Ingersoll-Rand and others who know they can depend on TMW for quality, accuracy and on-time delivery at minimum costs.

For more details, or for new Facilities File Folder call or write today.

TEXTILE MACHINE WORKS
CONTRACT DIVISION, READING, PENNA.



Announcing

the ALL NEW

MODEL

SA

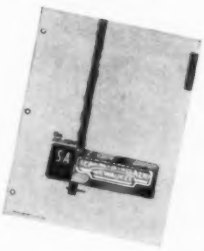
5hp

KNEE TYPE
MILLING MACHINES

KEARNEY & TRECKER EXCELLENCE

SMALL INVESTMENT

We'll mail a copy of Bulletin SA-61 immediately upon receipt of your request.



Since 1898

KEARNEY & TRECKER MILWAUKEE ®

KEARNEY & TRECKER CORPORATION

6800 West National Avenue • Milwaukee 14, Wisconsin, U.S.A.
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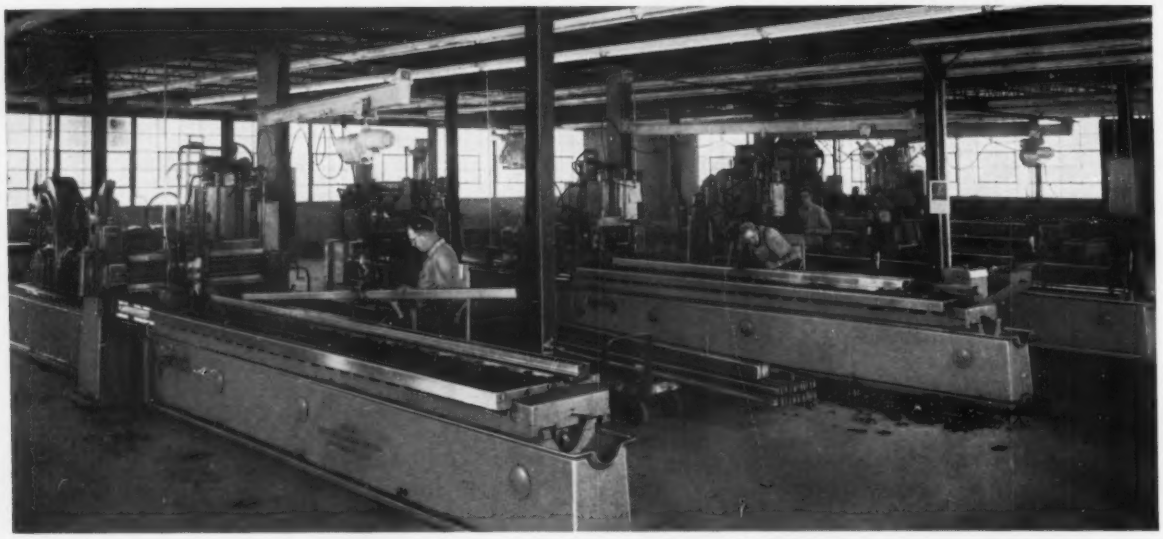
PRESS BRAKE DIVISION
THE VALERON CORPORATION

chooses Rockford Hy-Draulic Planers for High Speed Production and Versatility



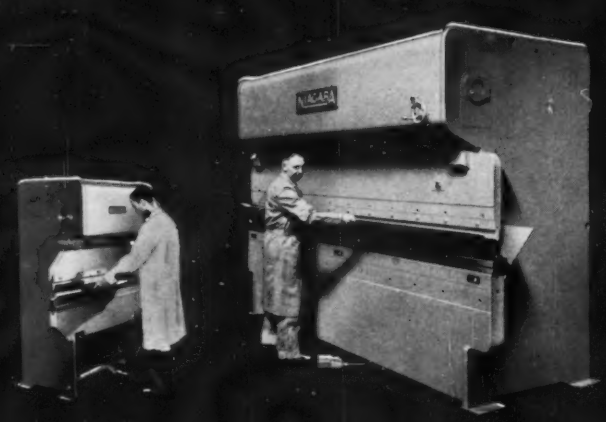
The Valeron Corporation, prominent carbide cutting tool manufacturer, in establishing their new Press Brake Division at Addison, Illinois, selected Rockford Planers for their efficiency in using carbide tools.

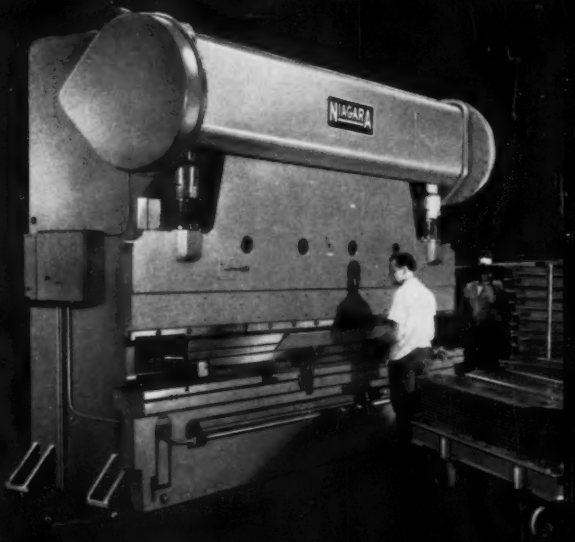
Battery of five Rockford Hy-Draulic Planers handles a variety of dies on a high-production low-cost basis, with advantage of quick-change flexibility. These are samples of dies showing multiple versatility.

Extra length work in a variety of shapes is easily machined on Rockford Hy-Draulic Planers, using Kopy-Kat hydraulic duplicator and multiple tool heads.

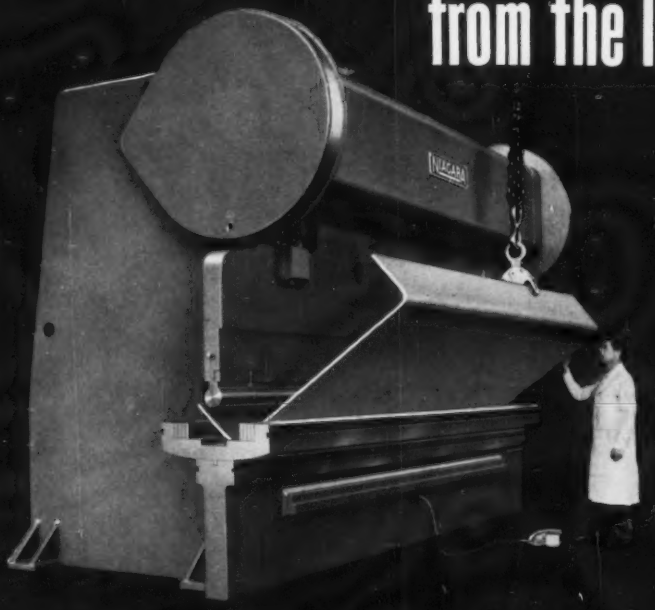
Send us drawings or sample work for estimates on your production.

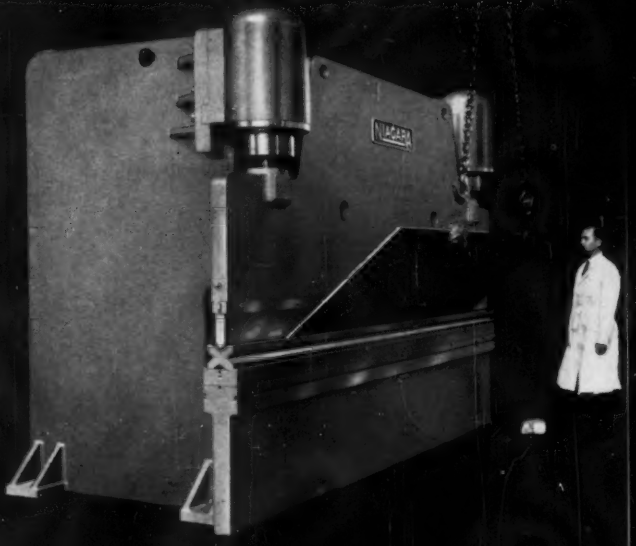
ROCKFORD MACHINE TOOL CO., ROCKFORD, ILLINOIS





MAKE THE RIGHT DECISION
from the line that means the most





With men who know their press brakes, Niagara means the most. Mechanical or hydraulic, there's a tremendous choice of sizes and bending capacities in a 15-1000 ton range. From 121 models, you're sure to make the right press brake decision.

Yes, you'll find it pays to talk "press brakes" with Niagara . . . for here you'll be talking with press brake people who not only build them all, but take pride in building them *best of all.*

Niagara can be your die headquarters too. "Standards" in stock . . . "specials" to order.

You're invited to check the Niagara Press Brake story . . . in fullest detail. Write for these illustrated bulletins.

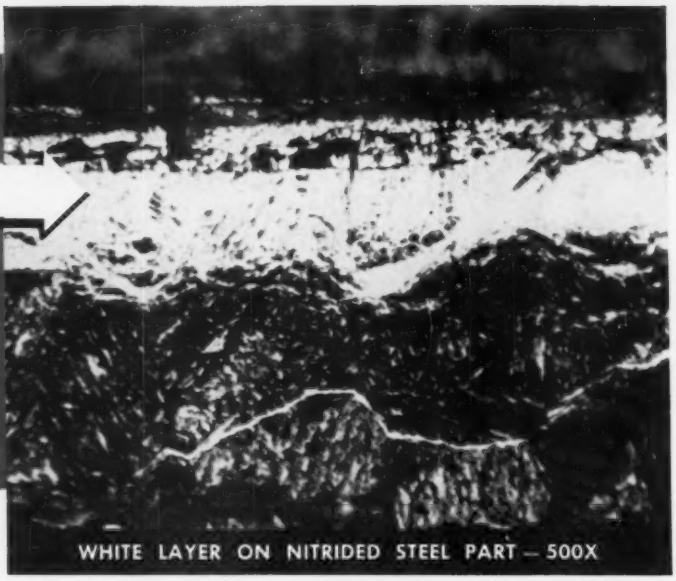
15, 30, 60 ton — Mechanical	Bulletin 90
90 thru 1000 ton — Mechanical	Bulletin 89
200 thru 1000 ton — Hydraulic	Bulletin 91
Dies	Bulletin 92

NIAGARA
PRESS BRAKES
mechanical and hydraulic

NIAGARA MACHINE & TOOL WORKS, BUFFALO 11, N. Y.
District Offices and Distributors everywhere.

America's most complete line of presses, press brakes, shears, other machines and tools for plate and sheet metal work.

REMOVE white layer FROM NITRIDED PARTS without grinding



WHITE LAYER ON NITRIDED STEEL PART — 500X

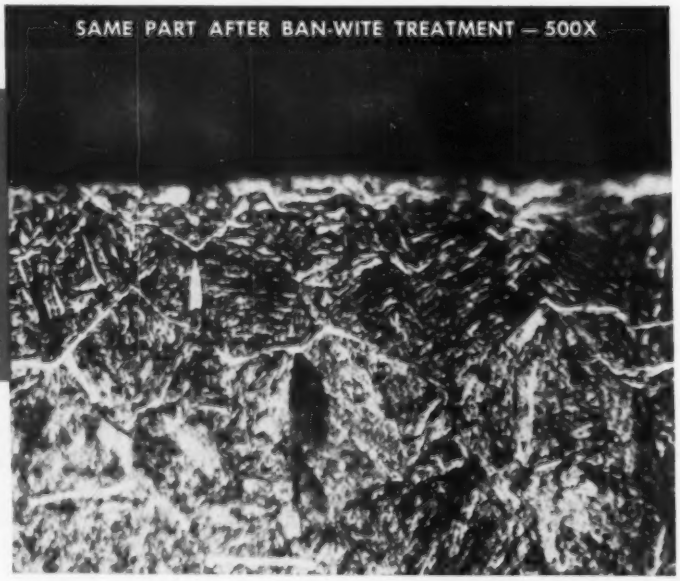
No longer is it necessary to grind the white layer off nitrided parts — gears, bearings, etc.

Now you can get rid of this blemish much more economically and without jeopardizing critical surfaces by grinding.

Your answer is BAN-WITE, a new metallurgical process (Pat. 2,960,421) developed by Red Ring Research.

This not only removes the objectionable white layer but it also tends to deepen the nitrided case. The danger of grinding checks is completely avoided.

Send your nitrided parts to us for treatment or, if you prefer, we will license you to use the process in your own plant. Either way, you save money and avoid rejects. Contact our local representative to get your jobs started now.



SAME PART AFTER BAN-WITE TREATMENT — 500X

WORLD'S LARGEST PRODUCER OF
GEAR SHAVING AND HONING EQUIPMENT

NATIONAL BROACH & MACHINE CO.

5600 ST. JEAN • DETROIT 13, MICHIGAN

Specify **SKINNER**

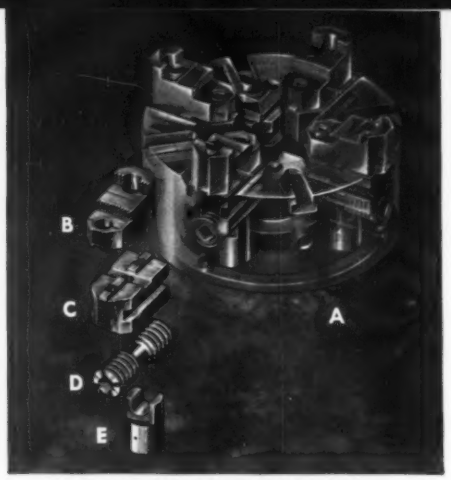
Independent Chucks for accuracy and long service in severest work

FORGED STEEL BODY withstands extreme jaw pressures developed on modern production lathes.

Large Diameter Operating Screws permit long range of jaw adjustment and assure precision control of jaw movement.

Hardened Steel Solid Thrust Bearings absorb end thrust on flat parallel faces and are rigidly fitted to the chuck body.

Accurately Ground, Hardened Jaws available in two-piece construction shown here, master jaw with reversible hard stepped top jaw—or one-piece solid hard stepped reversible jaw.



A—Transparent view of heavy-duty independent chuck
B—Hard, stepped reversible top jaw C—Master jaw
D—Operating screw E—Solid thrust bearing

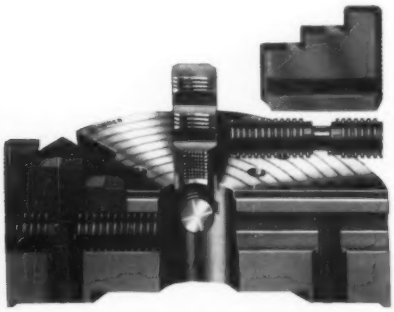
Superior Skinner design assures superior independent chuck performance

Skinner design achieves top chuck performance by combining separate parts of one chuck so that every part functions perfectly and in maximum support of other parts. See how the forged steel body surrounds more than 60% of the operating screw *for the full length of the screw*. Note the carefully machined jaw slots with heavy ribs to guide jaw movement and help hold jaw and screw in proper alignment at all times. See how the precision square threads of jaw and operating screw contribute further to even distribution of the strains set up by heavy gripping pressures. Every part is carefully made to exacting standards, and the whole chuck is *designed* to provide maximum gripping and accuracy.

Skinner heavy-duty independent chucks are designed for the rugged service required on modern turret lathes and have additional features such as:

- Wider jaws
- Larger and heavier operating screws
- T slots
- Specially designed bearings

An additional feature is the design of the master jaws below the face of the chuck, so that when top jaws are removed the chuck can be used as a face plate for clamping work.



Side view showing precise fit of operating screw, thrust bearing and jaw in medium duty chuck (solid jaws shown)

End view showing how chuck body surrounds 60% of screw circumference

General Information and Features	
Types and Sizes	Heavy-duty—12″ to 28″ Medium-duty—4″ to 36″ Light-duty—6″
Mounting	Skinner independent chucks are available for direct mounting on American Standard Spindles and for mounting on threaded spindle noses by means of separate adaptor plates.
Soft Blank Top Jaws	Standard height, extra high and long pointed sizes are available for heavy and medium duty chucks. Can be supplied or shaped to meet specific requirements.

Skinner manufactures a complete line of self-centering and combination scroll chucks, self-centering geared screw chucks, power chucks and accessories, packaged power chucking assemblies, and vises for milling, drilling and general machine work.

For complete details on Skinner Chucks and up-to-date information on major chuck developments, contact your Skinner representative or distributor, or write to us.

SKINNER CHUCKS®

THE CREST OF QUALITY

SKINNERCHUCKS

SKINNER-HORTON CHUCK DIVISION
SKINNER PRECISION INDUSTRIES, INC. • NEW BRITAIN, CONNECTICUT, U.S.A.

PRINTED IN U.S.A.

NOW 3-AXIS NUMERICAL CONTROLS FOR B&S TURRET DRILLS

HUGHES 3-AXIS NUMERICAL CONTROLS are now available as original equipment on Brown & Sharpe turret drills. With 3-Axis control, operation is completely automated—more work at less cost. Each spindle can be programmed for multiple drill depths. Feed speeds are tape controlled. Set-up time is reduced more than sixty per cent. And—as with all Hughes Numerical Controls—jigs, fixtures and templates are eliminated. Fitting 3-Axis controls to B & S turret drills is another "first" for Hughes. And you get proven reliability through Hughes' long experience in numerical controls. Hughes' transistorized circuitry, modular construction, and photo-electric tape readers mean more "up-time," increased production and less maintenance. Hughes ULTRA-RELIABILITY adds up where it counts—in your profits.

SPECIFICATION SUMMARY

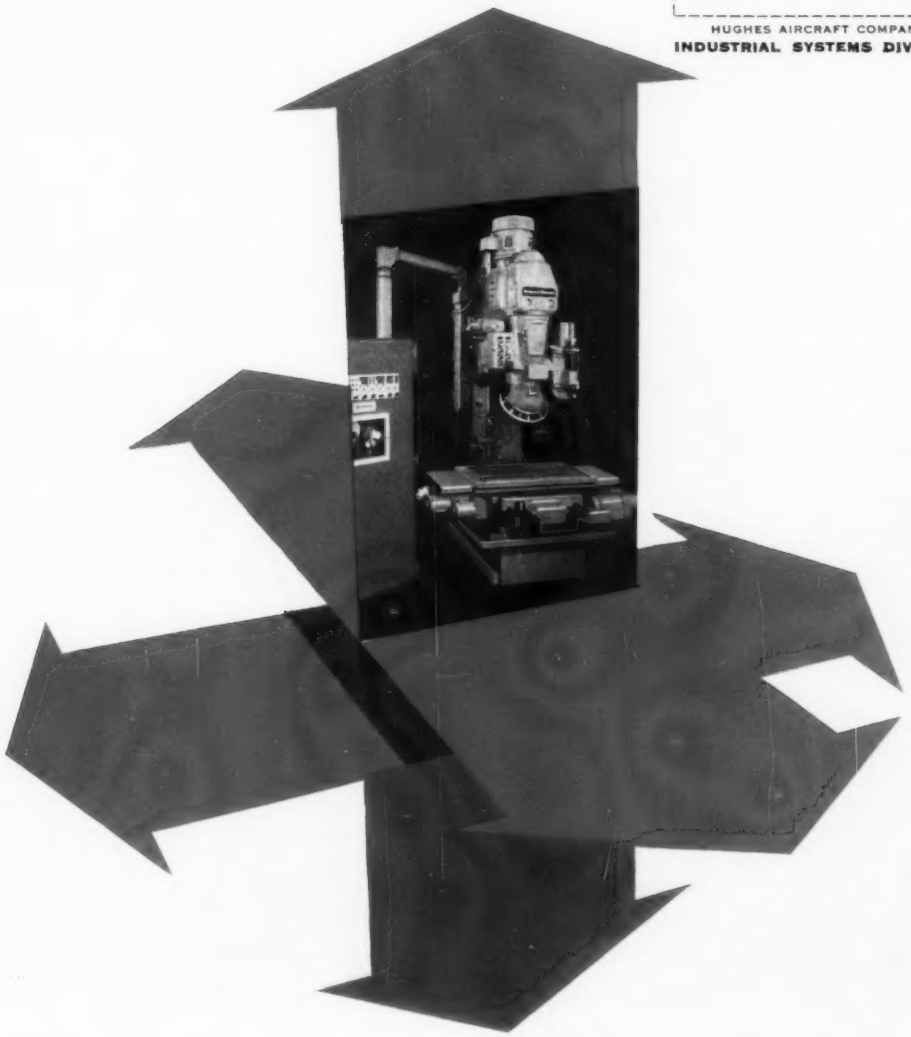
Axis controlled	X	Y	Z
Range of movement	20"	15"	9"
Accuracy	±0.001/ft.	±0.001/ft.	±0.002/ft.
Repeatability	±0.0002/ft.	±0.0002/ft.	±0.001/ft.
Position Speed (in./min.)	160"	160"	180"

Find out more about 3-Axis (or 2-Axis) Hughes Numerical Controls. Ask your B&S distributor, or write, wire, teletype (TWX INGL 4117) or call: Hughes Industrial Control Systems, Dept. No. 92-21, P.O. Box 90904, Los Angeles 45, California.

Creating a new world with electronics

HUGHES

HUGHES AIRCRAFT COMPANY
INDUSTRIAL SYSTEMS DIVISION



For more data, circle this page number on Readers' Service Card.

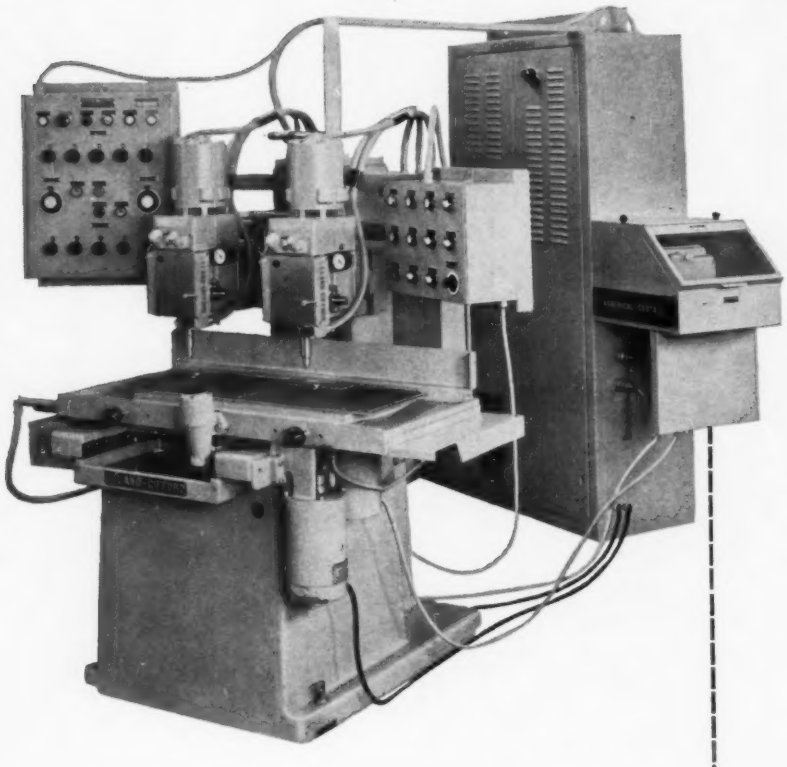
What does "Blanchard Ground" mean? Well, a glance at this sample case would show that it means finishes as fine as 2 microns. And a quick check with the optical flat below would show flatness to within 1 light band. What's more, Blanchards provide high precision, high production grinding of materials ranging from glass and stone, thru gems and plastics, as well as ferrous and non-ferrous metals. Equally efficient at hogging, too. Send for "The Art of Blanchard Surface Grinding" and get the whole story.
BLANCHARD GROUND
2MU
4MU
8MU
15MU
30MU
PUT IT ON THE BLANCHARD

THE BLANCHARD MACHINE COMPANY 64 State Street, Cambridge 39, Massachusetts

LELAND GIFFORD

PRINTED CIRCUIT BOARD DRILLING MACHINE

Operates in excess of 50 hits per spindle per minute — May be programmed by Flexowriter or direct from Art Work or Sample Board.



FEATURES

- Programmed by Flexowriter or direct from art work or sample board.
- Table position and spindle cycle actuated by G. E. Mark II Numerical Control with fast tape reader.
- Operates in excess of 50 hits per spindle per minute.
- Drills single boards or stacks.
- Up to four adjustably mounted, self-contained, hydraulic feed drilling units can be used.
- Table traversed hydraulically on ball-bearing mounted and guided round ways.
- High speed positioning by self-contained, closed loop, hydraulic circuits and reversible G. E. Thy-Mo-Trol controlled motor driven pump.
- Nation-wide control service available from General Electric Co.

Here is a practical, economical solution to the problems of fast, accurate production of electronic printed circuit boards. Combines the best features of the proven Leland-Gifford HOLE LOCATOR and the universally accepted modified G. E. Mark II numerical positioning control.

Hole patterns can be programmed by Flexowriter or directly from art work or sample board. Table can also be positioned numerically with control dials.

Up to four self-contained hydraulic feed drilling units can be employed, adjustably mounted on cross rail, to drill in excess of 50 hits per minute per spindle.

Write for detailed information and proposal — or ask to have an experienced sales engineer call.

SPECIFICATIONS*

Positioning accuracy	±.001″ non-accumulative
Repeatability	±.0005″
Table size	to suit requirements
Table travel	Standard 11″ x 15″ Optional 19″ x 15″
Overhang	14″, Optional up to 22″
Spindle nose to table	Maximum 10″ Minimum 0
Available stroke	up to 4⅜″
Feed rate	infinitely adjustable
Geared spindle speeds	500 Minimum to 7500 Maximum or 1000 Minimum to 15,000 Maximum
Floor space required	Machine 60″ x 50″ Control cabinet 94″ x 47″

**Subject to change. Dimensions are approximate.*

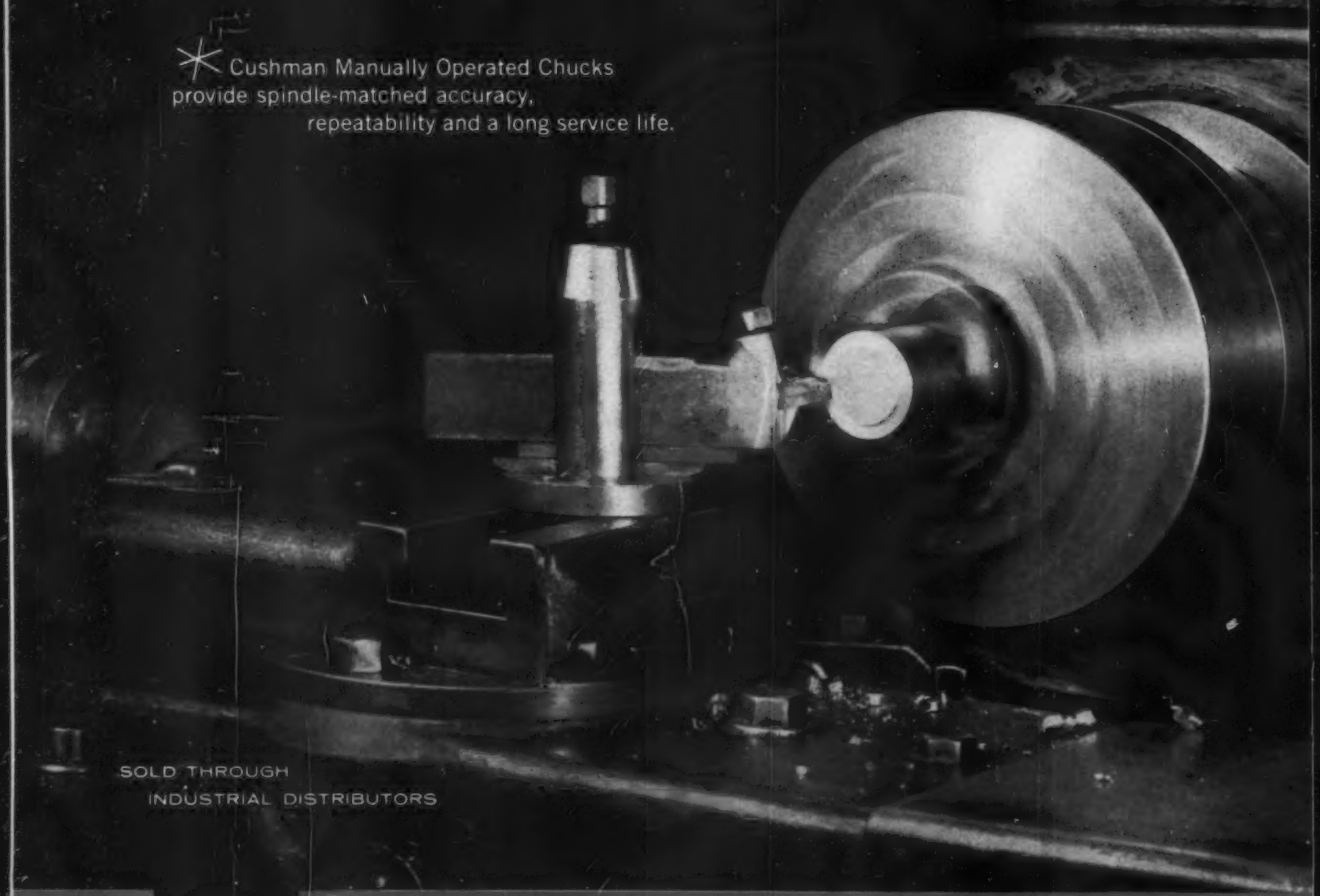
LELAND-GIFFORD
WORCESTER 1, MASSACHUSETTS

For more data, circle this page number on Readers' Service Card.

Relax! it's a Cushman chuck

CUSHMAN

MANUALLY OPERATED CHUCKS



* Cushman Manually Operated Chucks provide spindle-matched accuracy, repeatability and a long service life.

SOLD THROUGH
INDUSTRIAL DISTRIBUTORS

Cushman also manufactures air operated chucks, cylinders and accessory equipment, power wrenches, and face plate jaws.

THE CUSHMAN CHUCK COMPANY • HARTFORD 2, CONNECTICUT

Keeping up with Washington

Loring F. Overman

★ **Government Patent Licensing Policy Recommended**

★ **Machine Tool Modernizing Plan Outlined**

★ **Half-A-Loaf Tax Approach Opposed**

LOOKING FORWARD to 1970, when expenditures for industrial and scientific research may have reached $25,000,000,000 a year, the Machinery and Allied Products Institute is recommending that Washington outline a long-range policy for handling patentable inventions produced under government contracts.

The MAPI viewpoint is that the increasing interest in research and development will result inevitably in revolutionary advances in power production, transportation, communication, construction, and metallurgy. Since many of these will be the outgrowth of government-financed programs, MAPI officials say that a plan is needed to encourage participation in this research and to reward companies whose efforts are successful.

Government Patent Licensing Policy Recommended

In summarizing its position, MAPI recommends a government-wide license policy and opposes the adoption of legislative proposals S 1084 and S 1176, both of which require the Government to take title to the patents and fail to provide a workable licensing plan. It also opposes a recommendation that the Department of Defense patent policy be made to conform with that of civilian agencies where both are investigating a single field of knowledge with the same contractor.

"Any legislation which may be considered necessary should require as a general rule that patent rights be granted to R&D contractors with an irrevocable, royalty-free, nonexclusive license to the Government to practice or have practiced for it the invention involved. If in the judgment of the Congress it is necessary to reserve expressly a right for Government to the title in unusual circumstances, any exercise of such right should be conditioned upon a justification of such acquisition in accordance with such criteria as may seem appropriate to the Congress."

Machine Tool Modernizing Plan Outlined

The Air Force is reported to be vigorously pushing its machine tool modernization plan, as recently announced to the National Machine Tool Builders' Association. Proposed is a ten-year program which would replace conventional machine tools with "modern" types, many of them automated.

Currently the program is in the initial stage. Top-level Air Force officials are reportedly favorable to a stepped-up program of machine tool modernization. Other Defense Department policy makers must be convinced of the need, however, before their support can be placed behind efforts to finance the plan.

The Air Force is aiming at four goals—reduction of tooling costs, elimination of human errors, assurance of exact repeatability, and minimizing of machine variables. These goals are dictated by a shift from quantity production to small runs requiring precise control. Spokesmen for the program noted that the materials to be used in advanced space vehicles must be formed "to tolerances expressed in millionths of an inch."

One effect of the shift from mass production will be to reduce the number of machine tools in the Department of Defense inventory. Plans of the Air Force for the next five years, for example, contemplate replacement of 10,000 obsolete machines with 2500 modern ones. The same 1-to-4 replacement ratio may continue in other departments, it was indicated. The drop in number is not expected, however, to be accompanied by a corresponding reduction in dollar value.

Winston Churchill's famous comment, "Never did so few do so much for so many," is recalled in contemplating the machine tool industry's contribution to the national defense effort.

For example, in support of the Air Force modernization program, spokesmen point out marked increases in funds earmarked for machine tool replacement. During fiscal 1959 $3,000,000 was spent; in 1960, $15,000,000. The 1961 period started out at $14,500,000 but this has been increased to $25,000,000, with further increases expected if the over-all modernization plan is approved.

In contrast, the Senate Aeronautical and Space Sciences Committee has been told that $1,700,000,000 appropriation for space exploration will be required for fiscal 1961. The total includes an increase of $549,000,000 recommended for fiscal 1962 by President Kennedy as a further boost to an appropriation for a manned trip to the moon and return. The recommended increase, ironically, is approximately the same as the machine tool industry's entire annual output in recent years.

Half-A-Loaf Tax Approach Opposed

Some 250 witnesses appearing for twenty days before the House Ways and Means Committee gave similar testimony. Almost without exception, representatives of business opposed a tax credit predicated on modernization expenditures in excess of current depreciation rates. More logical, they said, would be an over-all reduction in tax rates and a realistic adjustment of depreciation.

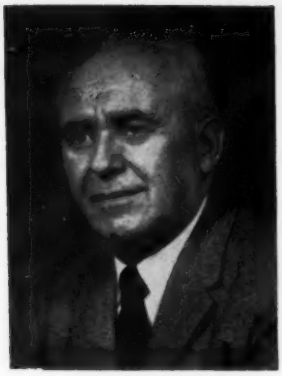
HARDINGE
ELMIRA, N.Y.

Electronic, Optical,
Computer, Gauge and
Instrument Manufacturers find
HARDINGE Machines essential
in the production of the
Super-Precision required.

HARDINGE BROTHERS, INC., ELMIRA, N. Y.
"PERFORMANCE HAS ESTABLISHED LEADERSHIP FOR HARDINGE"

OFFICES IN PRINCIPAL CITIES. Export Office—269 Lafayette St., New York 12, N. Y.

Machinery
AUGUST 1961



Someone Else Says It for Us

EDITORS of technical and trade magazines are often reticent about stressing the advantages that can be accrued by constant reading of the pages that are published monthly or weekly under their direction. Their reticence can be attributed to a feeling that listeners or readers might consider the editors to be immodest in appraising their own efforts or at least be prejudiced in their favor.

It is therefore gratifying to find a fluent champion of the business press in the person of Fred Wittner, president of a firm that has specialized for over twenty years in communicating to business and industry. In a booklet, "Why, When and How to Read Business Publications," Mr. Wittner cogently expresses the thoughts of most capable editors.

He says that "a man reads business publications because they contain information which is invaluable to him in his business life. For little or no cash outlay he obtains a master intelligence service and a continuing refresher course which cannot be had any other way. Time, systematically allocated, is the only thing really needed.

"The advantages gained from careful, conscientious and consistent reading of publications in the business or industry in which you operate can be set down explicitly and unequivocally.

"Business publications also spell, in a single word, survival—survival in the face of onrushing technological developments. Since most businessmen, production men, designers, etc., have little opportunity to return to college to update themselves, they are dependent upon the business press to keep them informed. Take the sections devoted to new materials, new products and new processes . . . the case histories of new challenges successfully met . . . the informative advertisements that fill the pages. They fill you in. They keep you up-to-date. These are your refresher courses. These are your cost-cutting lifelines.

"For an executive to say—as one hears so often—'I don't have time to read business publications' is to fill the air with an infectious sneeze in the disservice he does to the juniors who overhear him. On the other hand, the executive who makes a practice of clipping significant articles from business publications and routing them down the line or up the line with notations such as 'worth reading,' 'look into this' and 'for your information' is setting a constructive example that will be emulated throughout his organization and become a lifelong habit."

Copies of this informative pamphlet are available. Its pages explain in considerable detail a plan for getting the most benefit out of technical, trade, and business magazines.

Charles O. Herb

EDITOR

ONE KEY TO COST CONTROL IN '61

Savings like these through Metalogics*

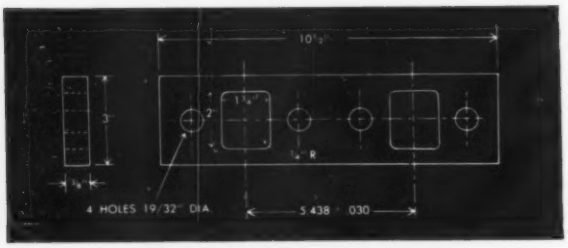
Look at these random examples and see how Ryerson Metalogics sparks real savings for hundreds of companies—in helping to search out new materials, new methods, new machines that will do the job better.

You can count on Ryerson for practical, unbiased recommendations because we offer you:

1. Exceptional knowledge of metals and their characteristics, gained through a century of service to industry as a supplier of metals and machinery for metal fabrication.
2. The nation's largest stocks of steel and aluminum —plus unsurpassed service on industrial plastics.

Your Ryerson representative is "Metalogics-trained" to help you value-analyze selection, fabrication and application problems. Get his constructive ideas soon, and see how he can help you select and apply material from our vast stocks. It's the "Metalogical" thing to do.

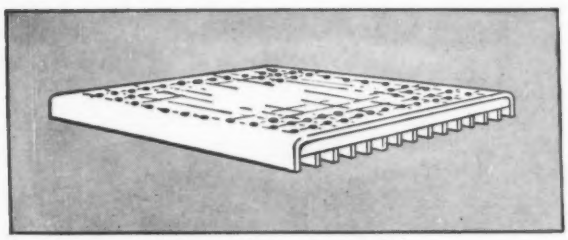
**The Ryerson science of giving optimum value for every purchasing dollar.*



Saved: $100 per thousand

PROBLEM: Muffler manufacturer required accurately finished mounting plates made from ⅜" x 3" bar. Cutting bars to size, burning 1¾" x 2" holes and drilling four 19/32" holes proved time-consuming and expensive.

SOLUTION: Ryerson recommended that they eliminate cutting, burning and drilling operations by stamping the part from Ryerson forming-quality plate. One operation instead of three cut costs $100 per thousand pieces and quickly justified the small initial investment in dies.



Suggestion saves 85%

ASKED FOR: Customer wanted 1" hot rolled plate to cover about 80' of 24" open trench. Plate was to be cut into 24" x 27" segments—each containing 900 ⅜" holes to filter the product.

RECOMMENDED: After studying application and costs, Ryerson recommended a design combining perforated light plate, formed to channel shape, and grating for structural support. Ryerson's experience and imagination saved 85% of the original cost.

Machine cut rings solve problem

PLATES REQUESTED: Ryerson was asked to bid on supplying ¼" Type 410 stainless in 27⅛" square plates. Material was to be used for orifice plates for 16" burner, subjected to elevated temperatures.

RINGS RECOMMENDED: Going beyond material specs, the Ryerson representative found that the customer intended to cut plate into 27⅛" diameter length with 13.120" bore—and then mill 12 slots in outer diameter for expansion relief. Knowing the application, Ryerson recommended supplying machine-cut rings in which slots could then be punched rather than milled. Production savings enabled switching to Type 304 at less cost than Type 410 with slots milled.

2 metalworking machines for the price of 1

A fabricator of stainless steel kitchen equipment was recently in the market for a new squaring shear. The one under consideration had a gap-type frame which would enable him to do an important notching operation—necessary for certain sink tops. After careful study, a Ryerson machinery specialist recommended *two* pieces of equipment instead of one at no increase in total cost. The first, an under-driven shear. The second, a universal-type sheet metalworking machine that would do the required notching, plus many other jobs—adding versatility to the entire operation.

Production upped 30%

BEFORE: Job shop was using MT 1015 tubing in the manufacture of this coupling. Machinability was satisfactory, but rising costs of operation led to a search for ways to economize.

AFTER: Careful study by the Ryerson representative brought about a change in material. He recommended using Ledloy® 170 tubing, which increased machining speed to 170 sfm and stepped up production 30%. Ryerson's stocks include the widest range of fast-machining alloys.

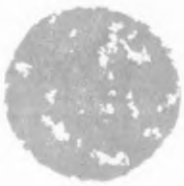
STEEL • ALUMINUM • PLASTICS • MACHINERY

RYERSON STEEL®

Joseph T. Ryerson & Son Inc., Member of the JMLAND® Steel Family

Machinery
Vol. 67 No. 12
August 1961

Discover vibratory finishing

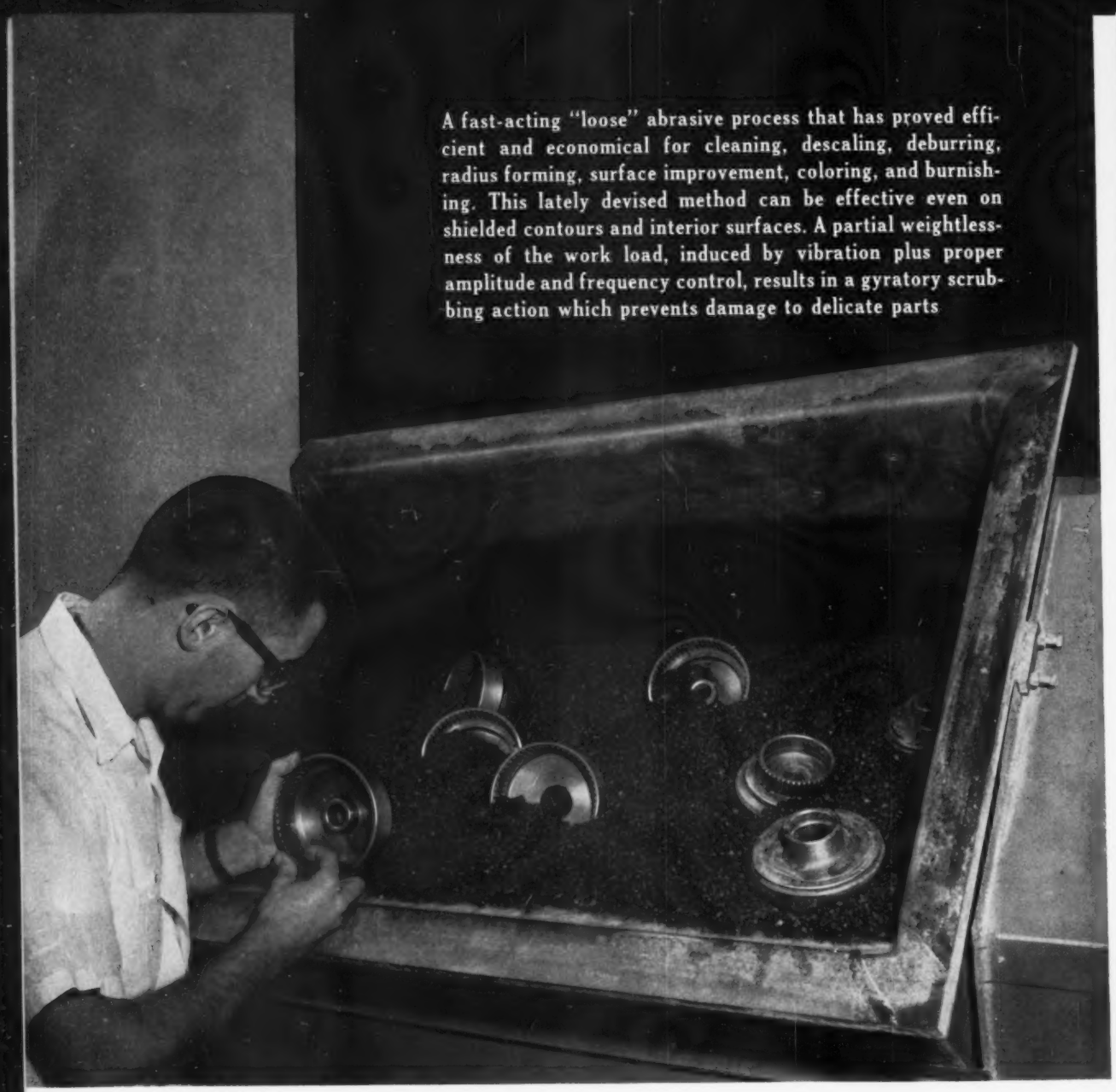


WILLIAM E. BRANDT, Vice-President
Pangborn Corporation
Hagerstown, Md.

VIBRATORY FINISHING, a recent innovation in loose abrasive processing, can best be described as fast, efficient, and versatile. The work-pieces are embedded in a mixture of media, compound, and water, and are subjected to controlled gyratory vibration in specially designed equipment. Through precise regulation of machine variables—such as duration of cycle, frequency, and amplitude—and the proper choice of media and compound, the nature and extent of the finishing achieved can be varied over a wide range.

Heavy scale, burrs (Fig. 1), or flash can quickly be removed. Radii can be formed to exact blueprint specifications. Surface roughness can be reduced to obtain low micro-inch finishes. In addition, parts may be cleaned, colored, or burnished. Any combination of these processes (Figs. 2 and 3) is performed without removing the work-pieces from the machine. More outstanding, however, is that the character of the work motion allows internal and extremely shielded surfaces (Figs. 4 and 5) of a part to be deburred or finished along with exposed areas.

The constant acceleration of the parts, media, and compound (and change in direction of their



A fast-acting "loose" abrasive process that has proved efficient and economical for cleaning, descaling, deburring, radius forming, surface improvement, coloring, and burnishing. This lately devised method can be effective even on shielded contours and interior surfaces. A partial weightlessness of the work load, induced by vibration plus proper amplitude and frequency control, results in a gyratory scrubbing action which prevents damage to delicate parts

relative motions) produces a scrubbing action that operates on all portions of the work load simultaneously, thus reducing cycle time to a minimum. Work containers can be almost completely filled and are left open for in-process inspection. Another useful result of the constant vibratory motion is to give the work load a partial weightlessness by reducing the effect of gravity. Since only a fraction of load in the container is ever allowed to act on all of the parts at any one time, the process is adaptable even to the finishing of delicate and fragile components for electronic tubes or textile machinery.

Vibratory finishing can be applied to practically all metal parts, whether ferrous or nonferrous, or whether cast, forged, stamped, machined, or pressed. In the heading illustration, steel transmission parts are seen being inspected after deburring in a Pangborn vibratory gyrator. Fused aluminum-oxide media were used with an abrasive compound.

The process is equally applicable to large or small parts. A section of a large stainless-steel rectifier roll, 24 inches in diameter, is seen in Fig. 7. This part is illustrated as it appeared after vibratory finishing in an 18-cubic-foot machine. It was held in a fixture and processed for two hours in fused aluminum-oxide media and compound.

When parts are processed while held in a fixture, normal cycle time is reduced one-half if the

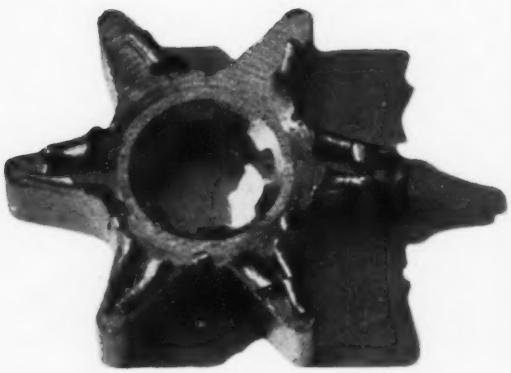
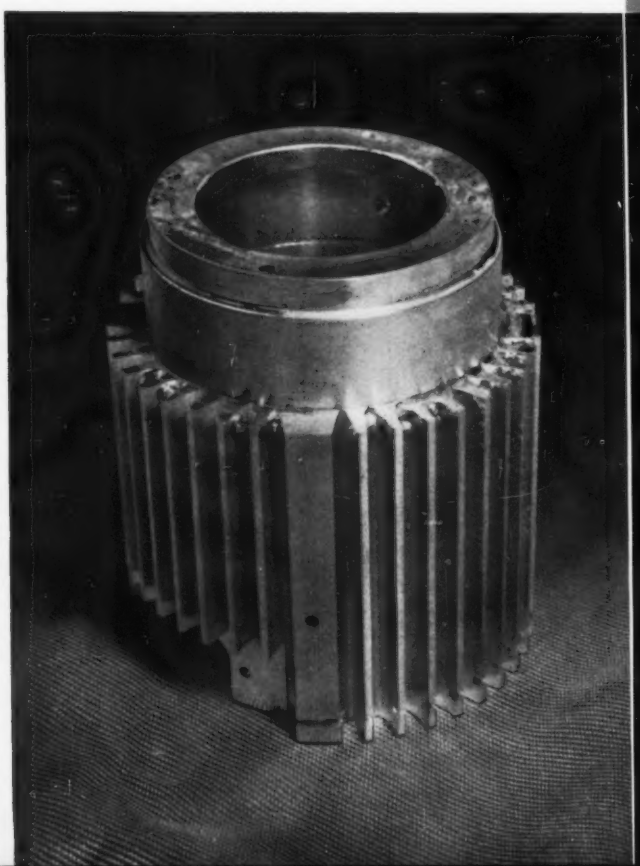


Fig. 1. (Above) Carbon-steel gears before (left) and after (right) deburring in a 6-cubic-foot vibratory-finishing machine in a one-hour fifteen-minute cycle. Because of the number processed, one piece is deburred every two seconds.

Fig. 2. (Below, left and right) The differences in these parts show extent of combined deburring, rounding of edges, and coloring operations on aluminum electric motor frames processed in a vibratory-finishing machine.

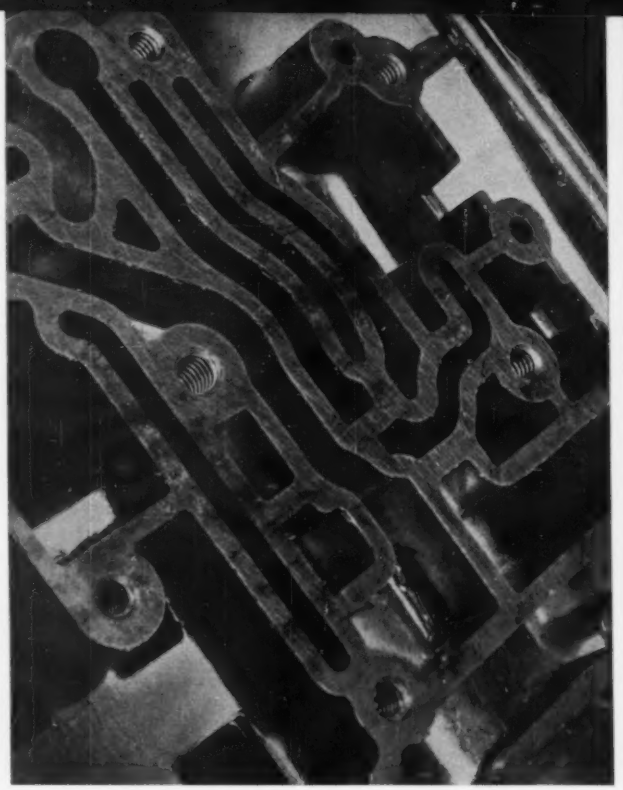


fixture is supported on the stationary frame of the machine or externally. When, however, the fixture is supported on the rim of the vibrating container—as is the usual procedure—the cycle time is again reduced by one-half. Such results are possible, since there are, in effect, two separate additive vibrations. It is readily apparent that this phenomenon can be used to good advantage, especially for the processing of stainless steels, titanium, and other hard metals. For example, a vibrator was able to improve micro-inch readings on forged and machined very hard stainless-steel turbine blades by 100 points in thirty minutes by using a fixture held on the work container.

Aircraft camshafts are deburred and their surfaces improved, thirty-nine at a time, in a twelve-minute cycle while held in the fixture seen in Fig. 6. The shafts snap into place over spring-loaded centers mounted on the two side-plates. An adjustable feature allows the fixture to accommodate various lengths of camshafts. The unit is designed to fit an 18-cubic-foot capacity Pangborn machine.

A manufacturer recently submitted metal bulbs 3 1/4 inches long and 3/4 inch in diameter, with a neck opening 7/32 inch in diameter and 1/2 inch long, for interior scale removal by vibratory processing. Even though the task appeared impossible, a test run was attempted. When a bulb was cut open after twenty-five minutes in the vibrator, a superb job of interior finishing had been accomplished.

Many firms using vibratory gyrators have further automated the machines as well as work-handling facilities to fit their particular lines and production setups. In conveyorized production lines, some firms process castings on a two- or three-shift basis in three-, five-, and ten-minute time cycles without stopping the machines, except once a shift to flush out abrasive sludge.



However, there are things that vibratory finishing cannot do. If, for instance, an opening, slot, or cavity is so small that no size of effective medium can enter it, or move in it, the vibrator cannot do the job. But even to this statement there are exceptions.

Machine Frequency and Amplitude Varied

To do vibratory finishing effectively, four things are required: (1) proper machinery, (2) the right media, (3) the correct selection of com-

Fig. 3. Stainless-steel turbine wheel before and after being vibratory-finished for descaling, surface improvement, and burnishing. Combined descaling and cutting cycle was one hour; burnishing required fifteen minutes. Part was fixtured, and fused aluminum oxide and compound were used.

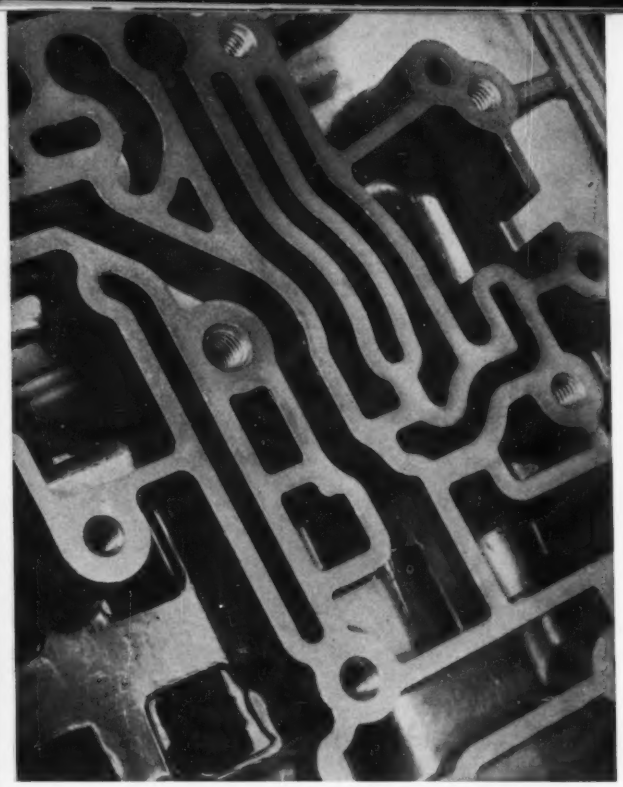


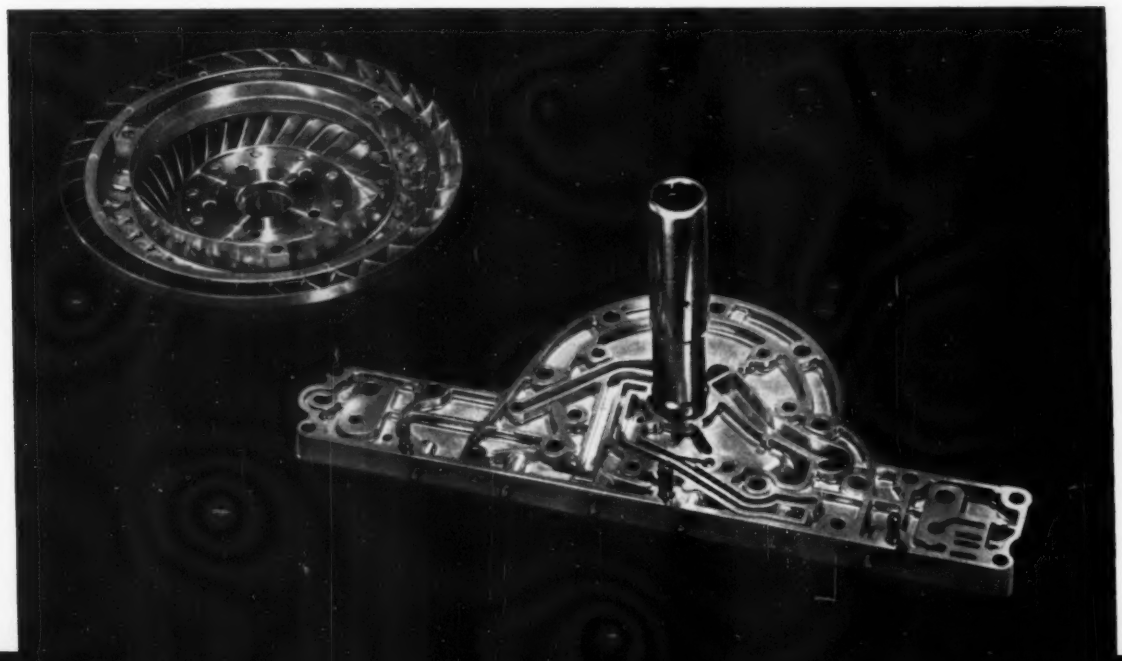
Fig. 4. Both shielded and exposed surfaces of this die-cast transmission part have been effectively finished in a twenty-minute vibrator cycle. Here, a section of the part is shown close-up before (far left) and after (left) processing.

Fig. 5. (Below) Effect of vibratory finishing on a die-cast automotive transmission part with other elaborate and shielded contours. The deburring and finishing were done with fused aluminum oxide and compound, also in a twenty-minute cycle.

pounds, and (4) an understanding of the technique. Of primary concern in the design of any vibratory-finishing machine is the type of work action that is produced. A pounding or impinging motion would be disastrous when a fine finish is desired. Straight-line vibration would technically prevent smooth and lustrous surfaces. The motion of the individual particles in the composite load relative to one another must be so controlled as to produce a positive, uniform gyratory scrubbing action, never subject to hammering or peening.

Such a vibratory-finishing machine is capable of a full range of action and is therefore a versatile piece of equipment. It should be provided with a means of varying amplitude as well as frequency. For example, the same combination of amplitude and frequency required for maximum stock removal may be entirely unsuitable for fine finishing or burnishing operations. Variable frequency and amplitude are also required when especially fine finishes and/or burnishes are to be produced on delicate high-precision parts where distortion must be avoided. Although amplitude will actually increase with frequency up to the point of the effective operating range, a variation of frequency alone will not suffice. Within the effective frequency range of an operation, amplitude increase is negligible or nonexistent. A vibratory-finishing machine that allows for increase or decrease of both amplitude and frequency, while in operation, has a much larger range of application than one limited to a fixed amplitude or frequency.

There are, of course, many other machine features to be considered. Available horsepower should be adequate for operation and yet be capable of economic usage. Differences in machine design can contribute materially to the reduction of maintenance, convenience, simplic-



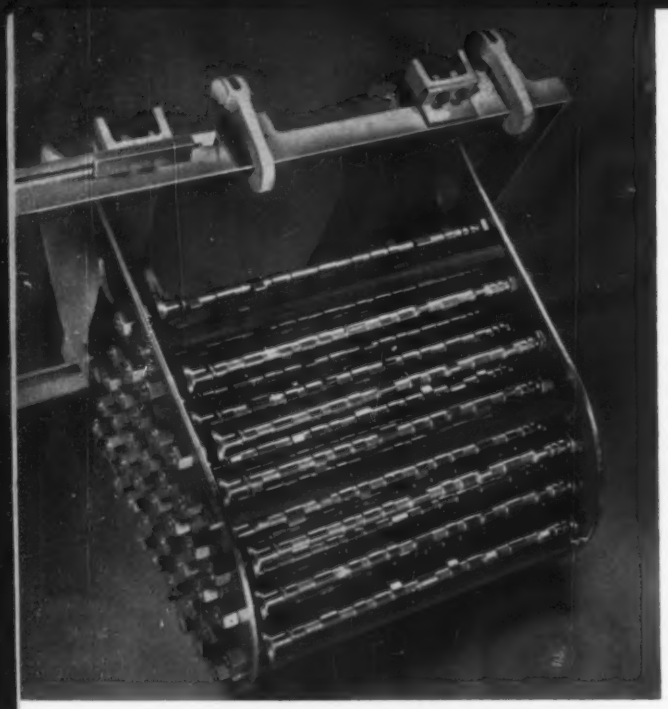


Fig. 6. Adjustable fixture with thirty-nine camshafts in position for vibratory finishing. Shafts will be deburred, and all surfaces will be improved. Entire operation takes twelve minutes in 18-cubic-foot capacity machine.

Fig. 7. This 24-inch diameter stainless-steel work-piece was held in a fixture and processed with fused aluminum-oxide media and compound in an 18-cubic-foot machine.

ity, compactness, quiet operation, and long life.

The construction of vibratory gyrators made by the Pangborn Corporation is illustrated in Fig. 8. In this equipment, the work container is vibrated by means of weights mounted eccentrically on a short heavy-duty shaft supported in a floating platform by closely spaced bearings. Removing and adding weights from this shaft is one means of varying the amplitude of vibration. Two sets of air cushions interconnected through a manifold suspend the floating platform from the rigid machine structure. Varying the air pressure to the manifolds provides a second method of adjusting amplitude. An annular type flexible coupling made of molded rubber absorbs vibration between the drive and the floating shaft during operation. In addition, variable-pitch sheaves on the belt-drive wheel allow adjustment of vibration frequency within a ratio of 2 to 1. For unloading, the work container can be tilted 120 degrees.

Fused Aluminum-Oxide Chips—an All-Purpose Medium

Although there are applications where other media are preferred, the accepted all-purpose medium for vibratory finishing is fused aluminum oxide. Depending on the purpose of the finishing operation, the action of this medium can be regulated from fast cutting, through any reduced degree of metal removal, to burnishing (Fig. 9) simply by use of the proper compound. By mixing appropriate media sizes, the work-pieces can remain in the work container until a series of finishing operations are completed. There is no unloading and reloading of work and media. Only the compounds are changed and the load rinsed between work cycles in a multiple-phase run. Even after the media have been so completely "loaded" that they act merely as burnishing balls, a quick rinse in a special detergent will restore their original sharpness.

Fused aluminum-oxide media are now manufactured with a fine crystalline structure. When properly made, the breakdown of these media is even and extremely slow. Also, the fracturing off of tiny pieces has all but been eliminated. They are available in a wide selection of precisely graded size ranges. This is important, since selection of the wrong media size or combination of sizes can prevent desired results. Pangborn fused aluminum-oxide media are shown in Fig. 10.

In certain applications, abrasive preforms made in shapes such as those illustrated in Fig. 11 may be required. These shapes consist of bonded and kiln-fired aluminum-oxide grain or silicon-carbide grain or grain mixtures, or a combination of both. Ceramic triangles (Fig. 12) are also advantageous for some operations. Although having little or no cutting ability of its own, this long-life medium has a textured surface that serves as a carrier for certain abrasive and burnishing compounds. In Fig. 13, die-cast parts

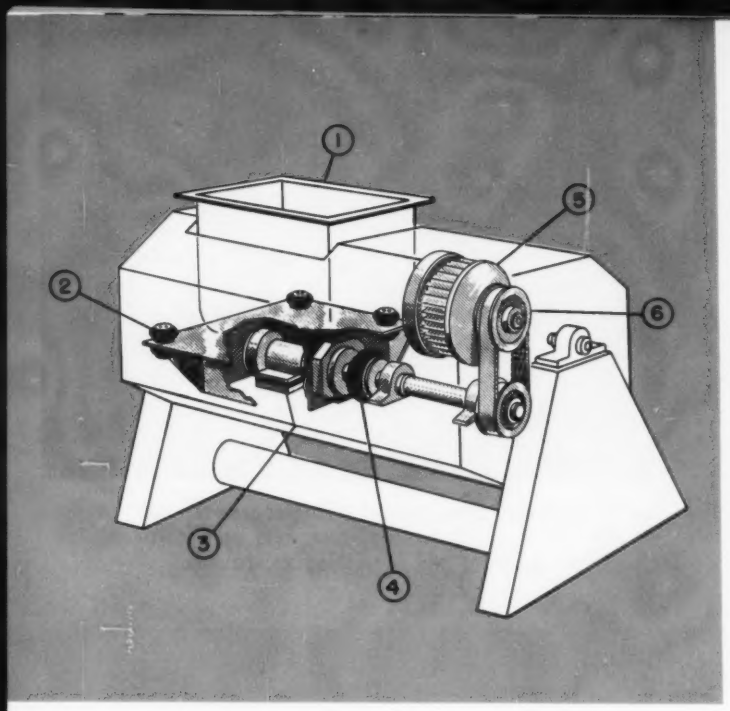


Fig. 8. Constructional features of a Pangborn vibratory-finishing machine include: (1) work container, (2) air cushions, (3) adjustable shaft-mounted eccentric weight, (4) annular coupling, (5) motor, and (6) variable-speed sheave.

Fig. 9. Couplings before and after vibratory finishing in a forty-minute deburring cycle and a ten-minute coloring cycle, using fused aluminum-oxide media and compounds.

are seen being removed from an 18-cubic-foot capacity Pangborn vibratory gyrator after finishing in a fifteen-minute cycle with ceramic triangles and compound.

Steel media (Fig. 14) are sometimes used with appropriate compounds for deburring, cutting, coloring, or burnishing. The shapes employed include double-pointed pins, slightly flattened and perfectly spherical balls, cones, balcones, diagonals, and ovals. Whereas soft-steel shapes (with abrasive compounds) are used for cutting and deburring, casehardened or through-hardened steel media are for coloring and burnishing.

Compounds Serve Many Purposes

Regardless of how perfectly the machine is designed, and in spite of all that has been said here concerning the importance of using the right media, no vibratory-finishing operation could be done successfully in the absence of the proper compound. Whether the operation is cleaning, descaling, deburring, radiusing, grinding, fine finishing, coloring, or burnishing, without a suitable compound the work-pieces would be discharged from the work container chemically unclean, impregnated with abrasive, and

Fig. 10. Fused aluminum-oxide chips are the most-used all-purpose media for vibratory finishing. Here shown are two forms of these media, both of which are available in a wide range of precisely graded sizes.

Fig. 11. Abrasive preforms are used for certain special applications. These are made of bonded grains of aluminum oxide and/or silicon carbide.

Fig. 12. Although these ceramic triangles are essentially nonabrasive, their textured surface acts as a carrier for certain abrasive and burnishing compounds.

almost always unfit for any further processing.

Just as the word *compound* indicates the presence of a multiplicity of materials, the purposes of the compound are multiple. If, for instance, an abrasive compound were used where an abrasive medium were also employed, the abrasive material in the compound would obviously serve only to further expedite the grinding or polishing action of that in the medium. This may be important in any given application, but it is only one of many functions a compound must perform.

Every compound should possess detergency or cleaning ability. Not only must the work-pieces be kept clean, but the abrasive medium, which is constantly shedding microscopically fine particles during use, must be kept clean and sharp. The "pores" must be kept open. A compound must also impart rinsability to the working solution. Both detergency and rinsability are often supplied, in part, by synthetic detergents that are compatible with the complete compound formulation. If the work-pieces are made of ferrous metals, anticorrosion agents must also be present.

In any event, a compound must have the ability to hold in suspension any microscopically fine particles originating from either the metal or abrasive during processing. These fines would otherwise be rubbed into the work-pieces, making it impossible to ultimately obtain virgin-metal color, clear luster, or chemically clean surfaces. Unclean surfaces, of course, would interfere with subsequent operations such as machining, welding, brazing, soldering, buffing, or plating. The soil-suspending agents employed might be soap, carboxy-methyl cellulose, or other synthetic materials.

Certain cushioning and/or lubricating agents are required even in abrasive compounds. They may range from mere foam of low density to lubricants which could control cutting action to any desired degree. Water conditioners must be supplied, and brightening agents are often present in the form of phosphate-salt combinations. Finally, buffering or inhibiting, and shelf life, as well as other properties, must be considered in formulating a compound.

Because of the differences between metals, and the differences between the nature of the various operations, a wide selection of abrasive compounds is required. Many times nonabrasive cutting or deburring compounds are used. In these cases the abrasive medium alone does the actual grinding, while specific agents in the formulation expedite the cutting action to a substantial degree. There are also short-cycle cleaning or bleaching compounds for various metals or alloys. It is important to realize that compounds of this type that are intended for use with certain ferrous metals might "burn" or blacken copper alloys, and vice versa. Burnishing compounds are specifically made for that purpose and cannot be expected to do descaling, just as descaling compounds cannot do burnishing.

A different deburring, cleaning, or burnishing compound, however, is not necessarily required for each class of metal or alloy. There are so-called all-purpose deburring or polishing, all-purpose cleaning, and all-purpose burnishing compounds which will do an exceptionally fine job on any metal or alloy. They are especially applicable to vibratory finishing; but, in spite of this, special compounds are often necessary.

The chemical composition of many abrasive

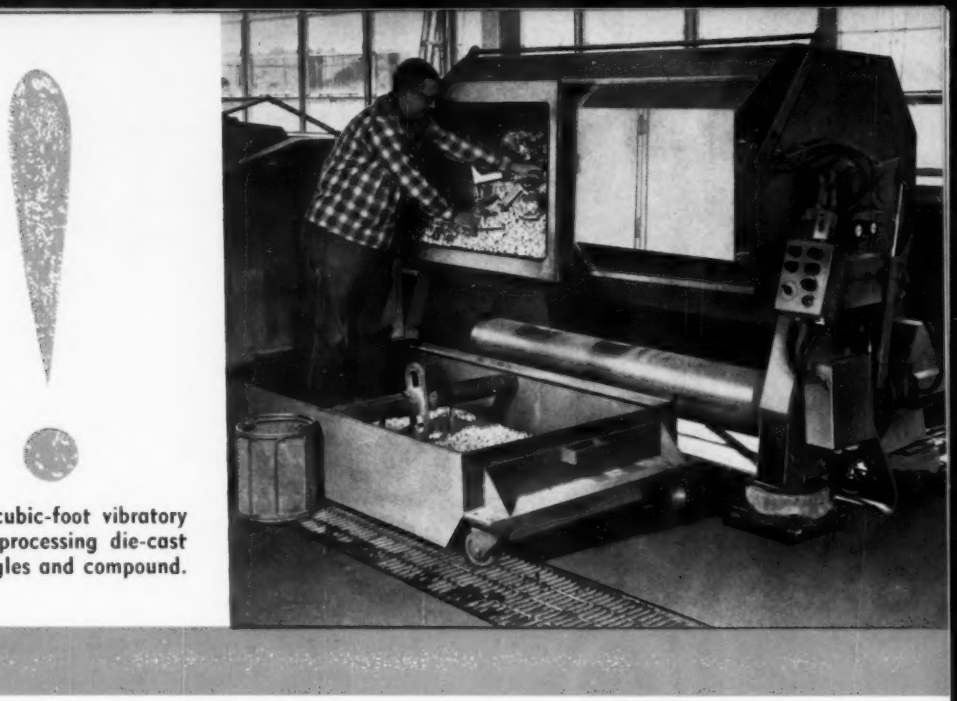


Fig. 13. Here, an 18-cubic-foot vibratory gyrator is seen after processing die-cast parts in ceramic triangles and compound.

compounds is much the same. The differences exist in the type of abrasive material and the grit size or size range of the fines. If it is desired to achieve much grinding, deburring, radiusing, or tool-mark obliteration on very hard metals, a very hard, tough, and coarse abrasive material is needed to sustain cutting long enough before the abrasive breaks down and only polishing is obtained. If less cutting is required on these same very hard metals, a finer grit of the same abrasive material in the same chemical formulation is used. On ordinary ferrous metals (inclusive of the milder stainless groups) regular aluminum-oxide grain will suffice, whereas the tougher and more expensive white aluminum-oxide grain is used for the very hard alloys.

Similarly, to perform work on softer alloys, such as aluminum and zinc die-cast alloys, a softer abrasive, such as silica in various grit sizes, is needed. If all that is required is to quickly reduce micro-inch readings on relatively smooth surfaces, a rather fine size range of abrasive will do. Thus, from only one coarse and one fine size range of the three types of abrasive material mentioned here, half a dozen different useful abrasive compounds can be produced.

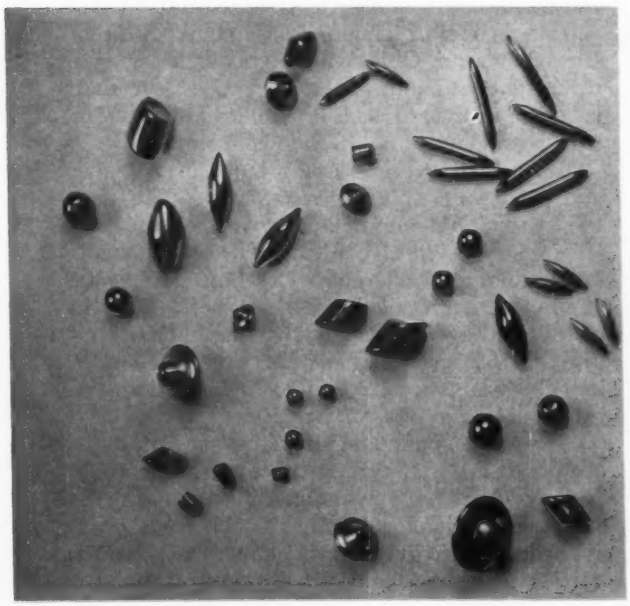


Fig. 14. Soft-steel media in these shapes are used for both cutting and deburring, whereas casehardened or through-hardened media in the same forms are effective for coloring and burnishing.

Quick-change tooling and multiple-stage fixturing cut blade dovetail forms on small-volume lots economically. Preset tooling trims down time in change-overs

Flexible Tooling for Continuous Broaching

LAURENCE W. COLLINS, Jr.
Associate Editor

CONTINUOUS BROACHING is a logical surface-machining process for long-run production. Correspondingly, it is usually expensive to employ continuous-broaching equipment for parts made in small quantities. An exception is at the Tapco Airfoils Works of Thompson Ramo Wooldridge, Inc., Cleveland, Ohio, which has found a way of using its continuous-broaching process for short runs—some as small as a few hundred parts. The trick is to do it "without losing your shirt."

Tapco is the world's largest supplier of blades and vanes for compressor rotors and stators, inlet guides, nozzle diaphragms, and turbine wheels in jet engines. Typical blades (Fig. 1) are made, in hundreds of different styles and sizes, from aluminum, 403 stainless steel (hardness: 30 Rockwell C and over), A-286 alloy, titanium, Hastelloy, and other special metals. The blade sizes broached range from 2 to over 16 inches long.

Production orders for blades usually run into the thousands, permitting machine setup costs to be spread thinly. Forming the blade-root profile (the dovetail) by conventional machining methods (milling, planing, and grinding), however, is not practical. To generate as many as a dozen related surfaces on each dovetail to close tolerances

makes Short Runs Practical . . . . . .

is not only costly by these methods, but blades cannot be processed rapidly enough to meet delivery dates. What is more, milling or grinding of these special alloys involves tremendous skill on the part of the machine operator. A considerable amount of experience and shop know-how is needed to generate the precise angles and accurate dimensions required. Costs are out of sight.

When the company began to produce turbine airfoils in large quantities, it was clear that meeting delivery deadlines was all-important. Tapco optimized blade-machining methods and found that continuous broaching was the ideal way to generate the dovetail surfaces quickly, accurately, and with a minimum of operator time and skill. Now, practically on an "off-the-shelf" basis, Tapco supplies blades of every style and dovetail configuration from its battery of continuous-broaching machines. These machines, Fig. 2, made by the Foote-Burt Co., Cleveland, Ohio, are semiautomatic in operation. No special operator skill is needed.

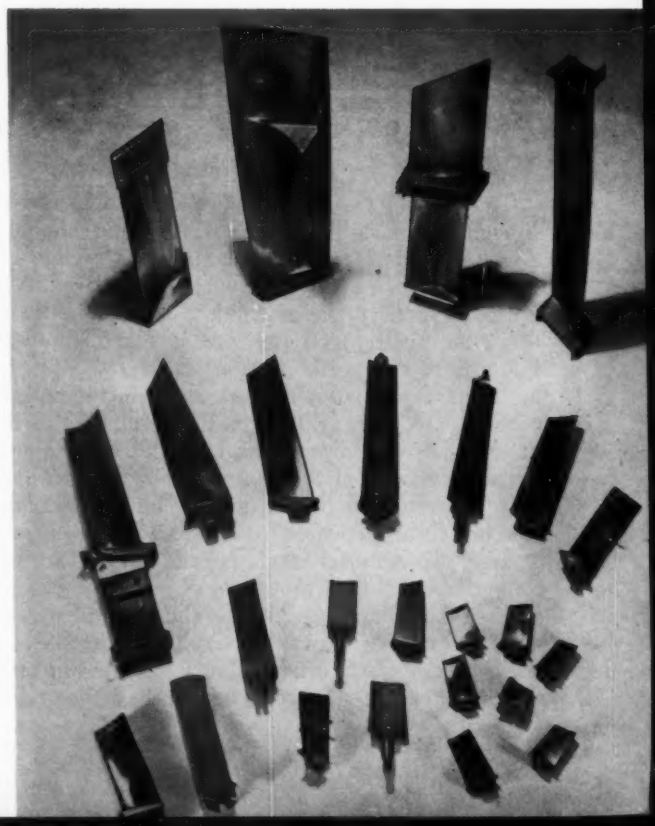


Fig. 1. Variety of jet turbine blades, buckets, vanes, and aft-fans "bluckets" is produced, using at least one broaching operation at the airfoil root.

Fig. 2. Platen fixtures carry work, clamped in pockets, through cutter tunnel to the left. Note the lift-off eyebolts in tops of the quick-change tool-holders of each broach.

Tapco faces two problems in scheduling short broaching runs. The first is broaching similar dovetails on blades of various sizes; the second is broaching the variety of dovetail profiles on several different styles of blades. To accomplish these multiple operations on a single machine, Foote-Burt engineers recommended the use of multiple-stage platen fixtures and quick-change cutter-heads. This means that the seven to fifteen fixtures carried through the broach by the continuous chain are arranged in "sets," with three or four different lengths of airfoil, but the same dovetail form, repeated in tandem. The quick-change, preset cutter-heads permit dovetail form change-overs with a minimum of setup time.

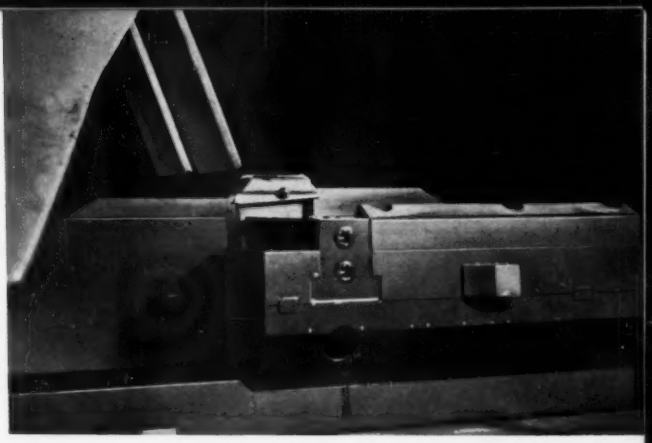
Briefly, a continuous broach (heading illustration) works as follows: a heavy, endless roller chain carries the work-holding fixtures from an operator loading station at one end of the machine through the broach "tunnel." The chain makes a 180-degree turn around the drive sprocket at the far end of the machine, and returns the broached parts and fixtures to the operator's loading station on the return flight of the chain under the tunnel. Chain speed is adjusted to the optimum cutting speed for the alloy being broached. The Footburt continuous broach employs a V-belt drive, permitting speed changes of the fixture chain as needed. Work-holder fixture clamps are special for each blade airfoil whose dovetail must be broached. The clamp pockets are interchangeable, as a part of setup.

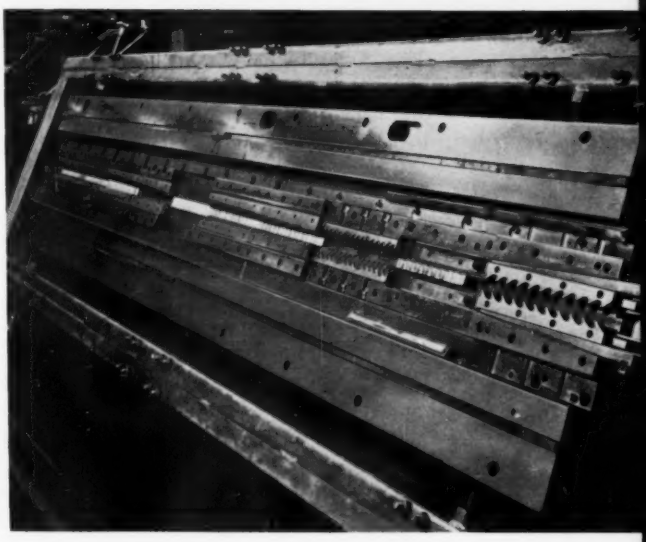
The operator simply places one blade—dovetail end up—into each fixture as it passes. A cam automatically closes the fixture, clamping the blade just below the root section, as the chain carries the fixture into the broach tunnel. An overhead safety gate, Fig. 3, is positioned at the

Fig. 3. (Right, top) Properly pocketed dovetail blank misses safety gate (the slanting plates, left center). Note the massive fixture platen holding the airfoil.

Fig. 4. (Right, bottom) Tandem arrangement of roughing and finishing broaching tools, in their quick-change holder, in the top of the broaching head.

Fig. 5. (Below) Each jet-engine blade goes into the broaching machine with its root form as-forged at the top (right). Broaching cuts finished profile at the left.

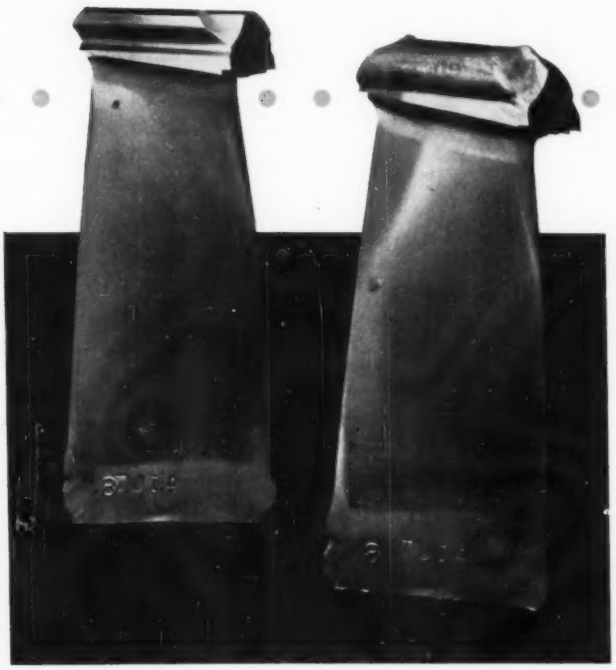




entrance to the broach tunnel to allow passage of the blade root if it is the right size for the pocket and has been properly inserted and clamped. But if a wrong part is in the fixture, or if a part is improperly located or clamped, it rides high enough to hit the gate. Moving the gate trips a limit switch interlocked in the drive circuit, stopping the machine.

Blades are carried into the broaching tunnel, where successive broaches remove stock from as many as twelve root surfaces in one continuous tandem pass. Fig. 4 shows how these paired profiling broaches are set in the quick-change toolhead. The first sets in the series rough out most of the metal, while succeeding broaches complete the part to a fine finish, Fig. 5.

The machine is practically noiseless in operation—an important factor where dozens of machines work in close proximity. The box type machine bed, heavily ribbed, is a semisteel casting for greatest rigidity. While the broach is cutting, its teeth are flooded with coolant or cutting oil (depending on the metal being broached). The fluid dampens noise and provides lubrication for the chain and fixtures. The Footburt broaches at Tapco range in size from 10 hp, with a maximum cutting length of 40 inches, through 30 hp and a maximum cutting length of 110 inches.



Normally, in high-production broaching, all fixture platens accept only identical blanks, with the operator loading every single pocket. But at Tapco, each pocket in a set of three or four on the platens may be different. For example, in one platen a blade of root form *A* can be loaded in pocket *A*, one of root form *B* in pocket *B*, and so on (Fig. 6). When all dovetails for a given type blade are identical, but the blade lengths are varied, the operator uses all fixtures, placing each

length of blade in the proper fixture pocket. By using the multiple-stage fixtures, Tapco can aggregate relatively small orders for each length of blade into a single larger order for one machine run when the dovetails are the same form.

When each blade has a different dovetail, however, the problem is not as easy to solve. Again, multiple-stage fixtures are employed, each fixture in a set being designed for a given blade airfoil or size. But only one blade style is run at any one time. When a new dovetail profile is needed, the company takes advantage of the quick-change head arrangement of the Footburt broaching machine. A typical machine has two interchangeable broaching heads, each of which can be tooled with two or more series of broaching teeth. While dovetails for one series of blades are being broached, the setup man is presetting the spare head with the necessary broaching cutters to broach the blade dovetail specified in the next production order. Since production demand is not often known far in advance, the spare heads must be ready almost at a moment's notice. At the end of an order, setup men simply pull off one broaching head, install the new one, and begin broaching the new series. Change-over time is short—rarely as long as two hours. If the cutters in the removed head are still sharp, they are stored in anticipation of future orders; if in need of sharpening, they are returned to the toolroom for grinding, before being stored.

The broaching heads on many of these Footburt machines are changed almost daily, giving Tapco's setup men plenty of experience in accurately presetting cutters. Once the correct broach setting is established, the head is bolted to the machine. The broach continues to produce on-size parts for the duration of the run. Setting broach tolerance on the Footburt head is easy, since the broaching cutters mount on tapered gibs that are easily adjustable "to tenths."

Using every third or fourth fixture in the continuous broach is not as uneconomical as appears at first. Many of these broaching operations utilize every inch available in the broaching head, and every ounce of power in the machine. Actually, chain speeds of most of the broaching machines at Tapco had to be regeared for lower surface speeds because the "superalloys," of which most blades are composed, offer high resistance to cutting. Higher speeds would cause excessive tool wear. Although only one blade may be passing through the cutter tunnel at any given moment, the motor of the machine may be drawing full amperage. Up to 3000 blades a day are machined by continuous horizontal broaching, as compared to a maximum of 1000 per day by vertical broaching on similar operations.

In addition to forming the blade-root profile, other Footburt continuous broaches are used to generate straight and angular end faces on blade roots. Fixtures locate the blade at the correct angle, clamping at the base of the root to provide maximum support during broaching. Dovetail position is established by means of a nub near the blade tip.

Tapco easily holds the required tolerances of 0.0015 to 0.0005 inches on most blades, using continuous broaching. On steel blades broaching is followed by grinding of the blade-root profile, but dimensions of titanium blades, as-broached, are well within the required tolerance.

Fine surface finish is a critically important specification of jet-engine blades, especially in the pressure angles of the dovetail, where the blade anchors to the turbine shaft or compressor disc. This area must be scratch-free and fatigue-proof to sustain the full stress of high speed and high temperature for a predetermined service life. As-broached finish on most titanium blade-root areas is usually below 32 micro-inches—and below 16 micro-inches on the pressure-angle face. This is sufficiently fine for immediate installation without grinding or other finishing. This fine finish is possible because continuous broaching is vibration-free. Blades of certain ferrous alloys, however, must be wheel-ground.

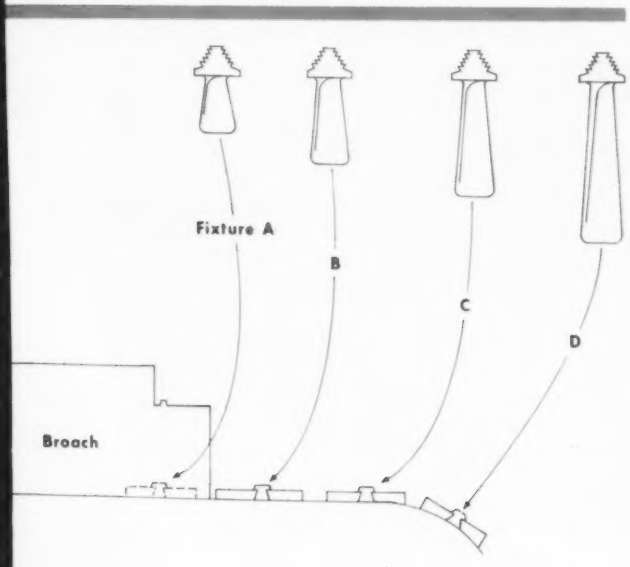
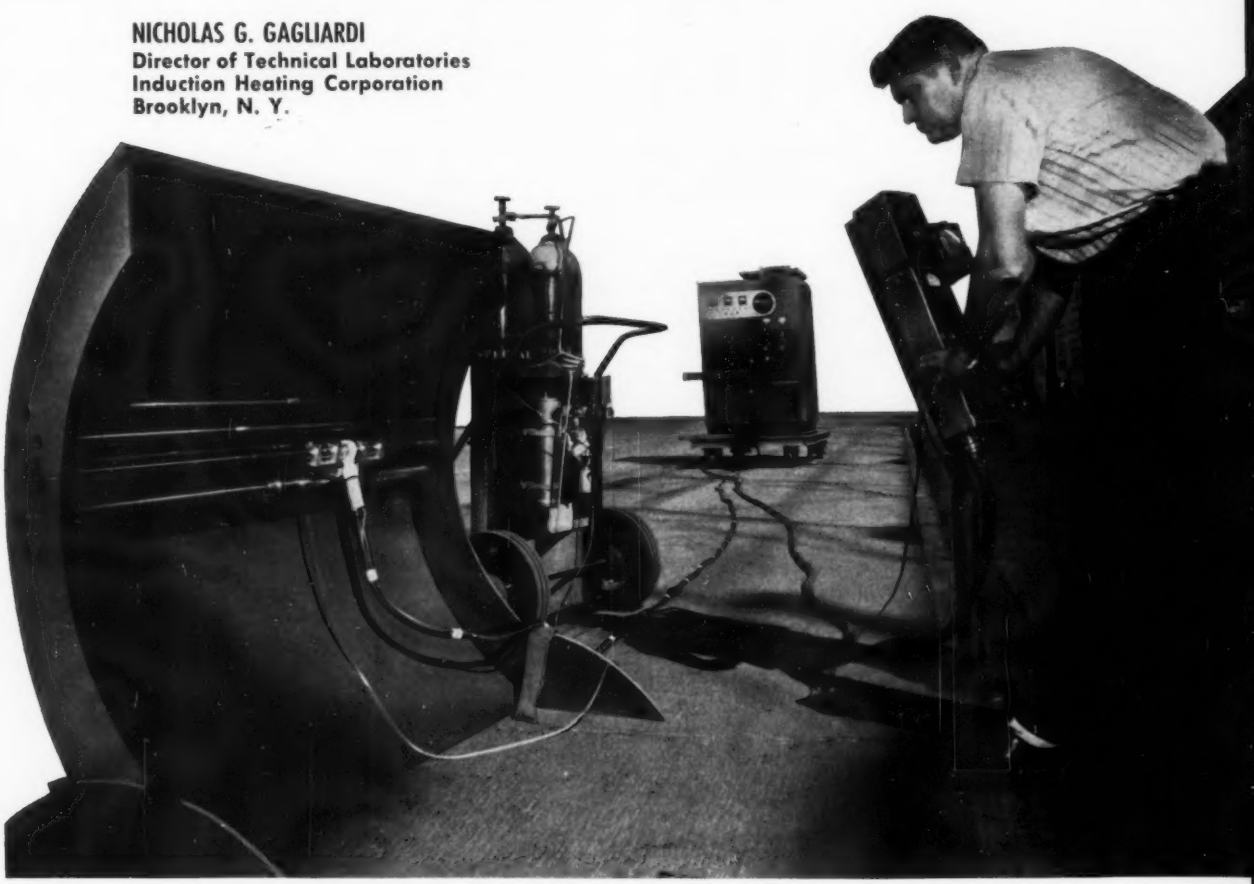


Fig. 6. Short-run tooling flexibility is made possible, when the dovetail form is the same, by tooling the platen fixtures with pockets for blades of various lengths. But in other short runs, where both dovetails and airfoils may be different, blades are set only into matching fixtures—every third or fourth fixture on the continuous chain. Each time the dovetail form changes, setup men replace the quick-change broaching head with another one containing suitable preset broaches.

Induction heating solves a variety of production problems

NICHOLAS G. GAGLIARDI
Director of Technical Laboratories
Induction Heating Corporation
Brooklyn, N. Y.



Uses for induction heating are numerous and equipment is versatile. Automatic machines and special fixtures turn many production bottlenecks into high-speed operations. This article describes some recent applications of the process for hardening, brazing, annealing, and soldering

VERSATILITY, precise regulation, and ease of automation are features that make heating by induction advantageous for many critical yet high-volume operations. Where careful control of heat flow is vital, the process is sometimes the only practical method by which a job can be accomplished. Often operations such as brazing and hardening are combined in a single setup.

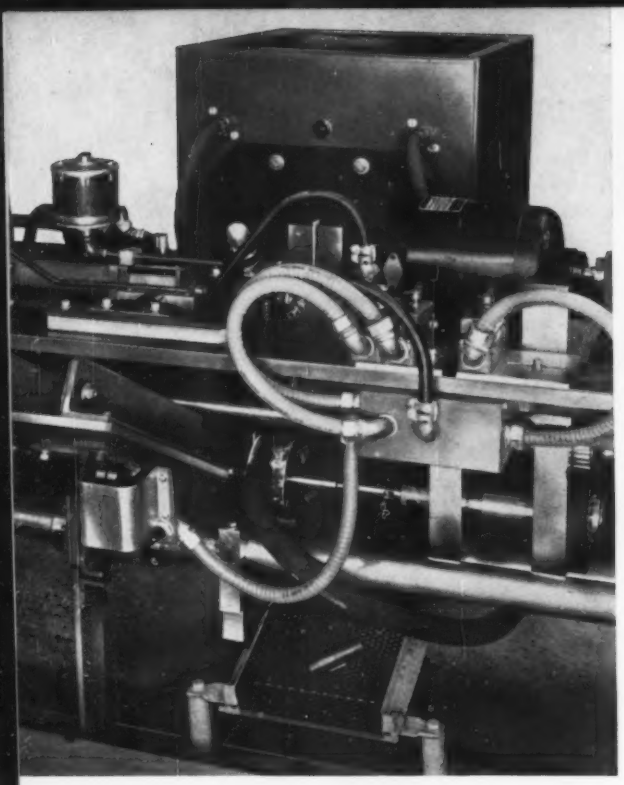


Fig. 1. Close-up view of automatic machine for induction casehardening of wrist-pins. Part is held between centers and moved axially through an induction-heating coil and water-spray quenching ring.

A fully automatic machine for the induction casehardening of automotive wrist-pins is seen in Fig. 1. Employed by a Mexican manufacturer of replacement parts, this equipment was developed by the Induction Heating Corporation, Brooklyn, N. Y., to process over 100 different sizes of wrist-pins from 1/2 to 1 inch in diameter and from 1 to 4 inches long. These pins are hollow and generally made from tubing. They are fed through a magazine hopper to a pickup station in the machine, where a pair of air-operated centers closes axially on each one. Held between centers, the pin is then rotated and moved rapidly lengthwise through an induction-heating coil and a ring type water-spray quenching unit. At the end of this stroke the centers release the pin and return at high speed for the next one. Rotation of the part guarantees a uniform hardness pattern. About 700 wrist-pins, 3 inches long by 3/4 inch in diameter, can be casehardened in an hour under fully automatic operation. The induction coil and quenching unit can be seen close-up in Fig. 1.

The machine, which can be adapted to many other cylindrical parts, is equipped with a 30-kw, 400-kilocycle oscillator. Parts are held between the centers under a pressure of 85 to 100 pounds, and the stroke cycle is controlled hydraulically. Wrist-pin travel through the induction coil is carefully regulated to obtain a 0.025- to 0.030-inch depth of case and a hardness of 60 to 65 Rockwell C.

Several coils are necessary to process the entire group of wrist-pins, with each coil being used for pins having diameters differing by about 3/32 inch. A safety device stops the machine if the parts are not properly held between the centers.

Brazing, Hardening, and Drawing in One Setup

Only six seconds are required to braze on a carbide tip and harden and draw each tooth of saw blades of the circular type in the induction-heating equipment illustrated in Fig. 2. No subsequent straightening of the teeth is necessary, since the heating is localized. The installation—used by a large manufacturer of circular steel saw blades—consists of a Ther-Monic 5-kw induction heater with dual outputs, a water-to-air heat exchanger (in the stand), and a setup with two work stations located at right angles. The right-hand output of the generator has offset adapters to permit the use of additional tooling without interfering with the main function of the arrangement. A selector switch on the control panel operates either output at its individual cycle time.

Since carbide tips are brazed to both sides of the circular saw blades on alternate teeth, only every other tooth is processed at one time. Once the blade is loaded, a tooth is manually indexed into place over the brazing coil. A carbide tip, together with a 0.0025-inch Easy-Flo No. 3 (silver-brazing alloy) preform, is placed on the tooth and accurately positioned by a lever-operated locator. Then a spring-loaded hold-down device is tripped and the locator is retracted. At this point the cycle button is pushed and the heating coils for both brazing and drawing are energized.

In brazing, the coil heats the blade tooth to approximately 1500 degrees F. to melt the filler alloy. Immediately after brazing is accomplished, an air blast quenches the high-carbon steel, producing a hardness of 63 Rockwell C.

The drawing coil is displaced a number of teeth from the brazing coil, in order to allow for further cooling after the brazing-hardening cycle, and is adjusted to heat the previously hardened tooth to the correct temperature in the same cycle time required for brazing. The final hardness after drawing is 55 Rockwell C, as specified by the manufacturer. A spring-loaded pawl holds the teeth in position until released for indexing.

Features of the setup can be seen in the close-up view of the fixture (Fig. 2). The blade-hold-

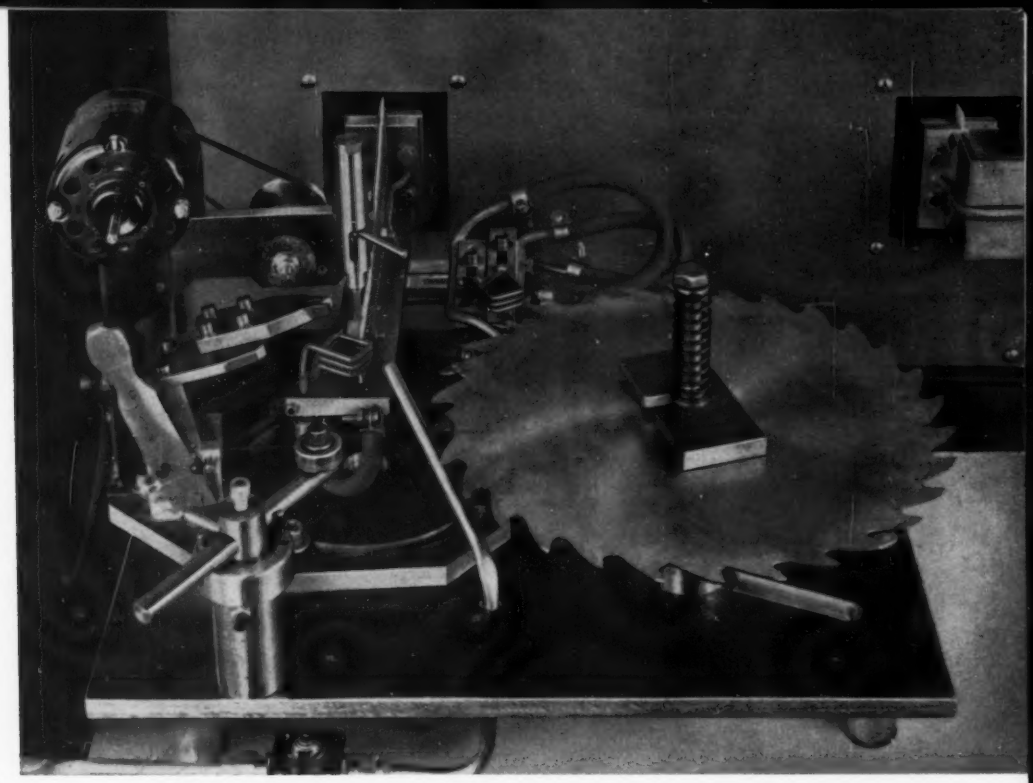


Fig. 2. In this setup, two induction-heating coils operate simultaneously to braze carbide tip and harden and draw steel teeth of circular saw blades.

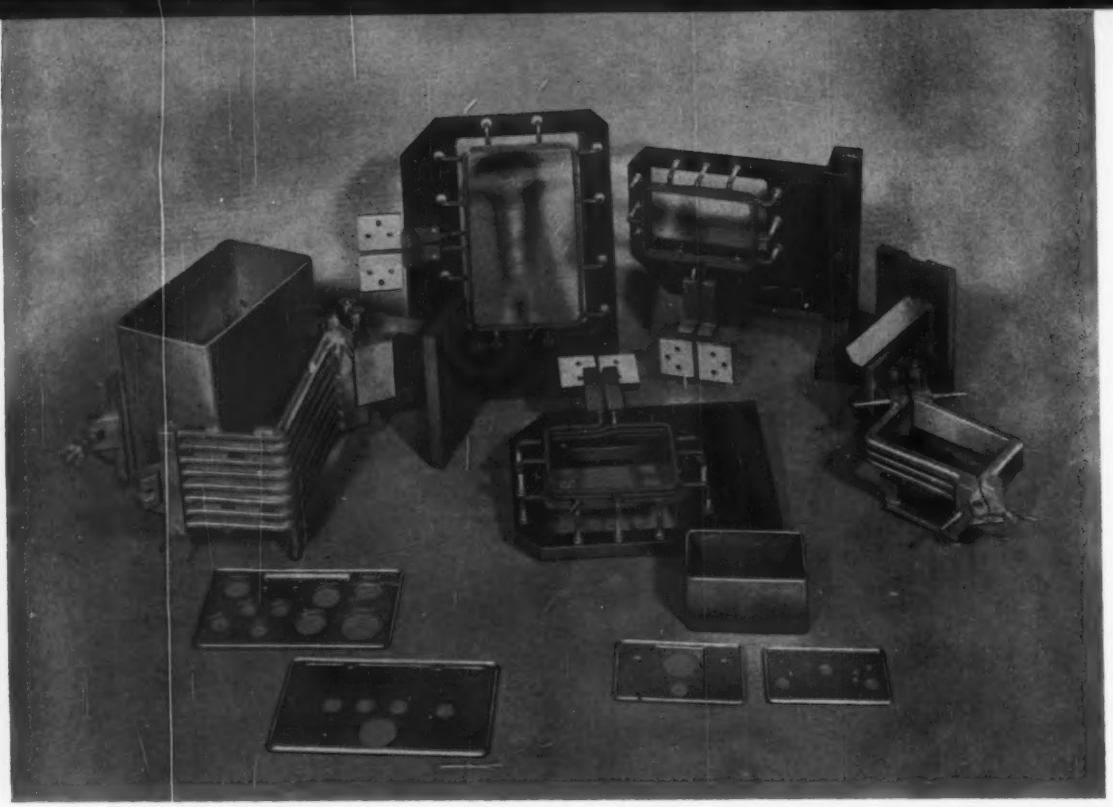
ing mandrel has a spring-tensioned hold-down for easy loading and is adjustable in a slot to accommodate all the various-size blades processed. The spring-loaded pawl is seen in the foreground directly over the air shutoff valve. The carbide-tip locator and the hold-down device are mounted on a swivel baseplate, together with a motor-driven wire brush used for cleaning flux from the locator. The baseplate is arranged to swing the locator and hold-down around the center line of the heating coil when the blade is reversed and the teeth face in the opposite direction. Work-coils are also adjustable for all sizes of teeth and blade diameters. Heating is done from the underside of the blade, giving complete freedom for loading tips and applying flux from the top.

Soldering, Unsoldering Instrument Cases

Instrument cases are often soldered with the aid of induction heating, but a recent application of the process is unusual. A particular group of expensive instruments of a type employed for military purposes are housed in cases ranging in cross-sectional size from 2 by 4 inches to 6 by 8 inches. In addition, some have cylindrical cases up to 4 inches in diameter. All cases are made of thin-gage aluminum which is first copper-plated and then tin-plated. The plating is done to facilitate soldering and permit the use of a noncorrosive flux. End plates on some of the instruments are made of cast aluminum and are designed with a groove to receive the sheet-metal case. These grooves also act as a well for the solder, which is applied preformed.

Water-cooling jackets (Fig. 3) constructed of copper, were designed in two hinged sections for each of the instrument cases. They consisted of several lines of tubing spaced evenly over the surface to effectively cool the desired areas. The clamps used to hold the two sections of the cooling jackets in place have a locking device and a gear train that opens both sides simultaneously when either side is opened. The inside walls of the cooling jackets, although covered in sections with a soft felt-like material, are still able to absorb heat from the desired areas. Two of the water-cooling coils, three induction-heating coils, and two cases and covers are shown in Fig. 3.

Pressure is applied uniformly by the clamps, allowing for thermal expansion, and in a manner to prevent breaking the glass window seals in the instruments. Excessive pressure could damage precision gear trains or hermetically sealed drive members. Also, improper contact with the cases could result in buckling or injury to the thermoplastic-insulated internal wiring.



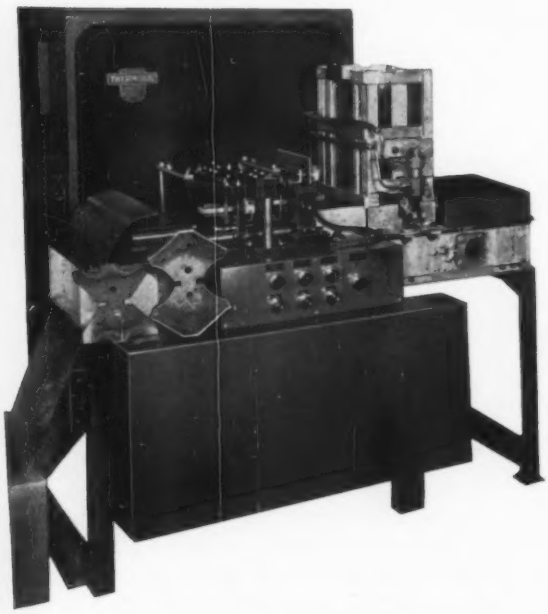


Fig. 4. This equipment automatically and simultaneously anneals four sections of bracket for an automotive application. Either of two different-size brackets can be processed. Operator simply fills feed hopper.

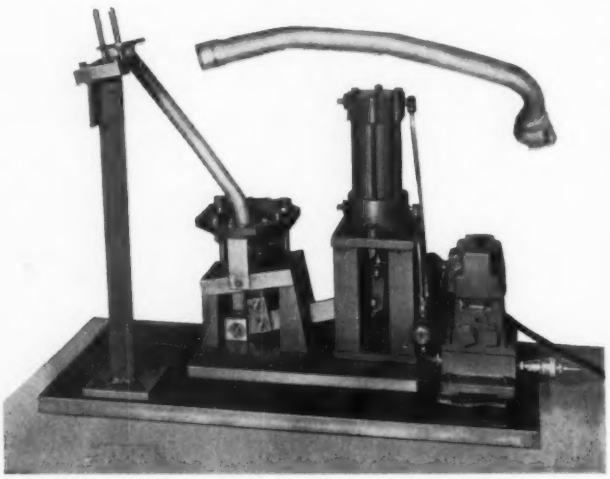


Fig. 5. One setup for induction brazing of fittings on fuel lines for jet aircraft and missiles. Titanium mandrel expanded in tube by air-operated cylinder spreads the filler alloy uniformly throughout the joint.

Fig. 3. (Left) Induction coils and water-cooling jackets used in the soldering and unsoldering of thin-gage aluminum cases containing delicate instruments. Cases and covers of two of the instruments are also shown.

The heating cycles for many of these operations are a little involved. It was found necessary to apply heat in intermittent periods of approximately four seconds "on," four seconds "off," to allow time for the heat to equalize by conduction. These cycles, of course, varied with the individual work-pieces.

Unsoldering of these instrument cases for repair purposes had also presented a problem, since repairs have to be made in the field in various locations and bases throughout the world. However, the same problem exists—that is, to unsolder the cases without causing any additional damage. The cases cannot be unsoldered with a torch or iron, due to nonuniformity of heating as well as the possibility of excessive heat being applied by these methods.

By following simple procedures, unsoldering is now being successfully accomplished in the field through the use of a 10-kw, 450-kilocycle-per-second induction-heating generator.

Annealing a Simple Task

Automatic annealing of four sections of a bracket for an automotive application is an excellent example of an effective use of induction heating. The previous method in this case was to stack the bracket plates and have a man with a torch heat the desired sections, or even the whole plate. This procedure was simple, but the heating was generally not uniform. In addition, the cost of the handling and rehandling of the parts was high. There was also much personal discomfort to the operator. Often brackets were over-annealed, or annealed in more than the required areas. As a result, some parts cracked, and the over-all rejection rate was high. After an engineering study, a machine (Fig. 4) was developed that not only heats the four sections of either of two differently sized bracket plates simultaneously, but also transfers the parts automatically.

The special tooling was installed on a single-position, all-steel modular-constructed unit containing all of the control circuitry and a Ther-Monic radio-frequency, variable-ratio output transformer which reduces work-coil voltage to a safe operating value. The coils are connected to a grounded secondary, which also helps to assure maximum safety for the operator and protects the coils. Another feature of the setup is a pressure-actuated switch which prevents operation when the proper flow of cooling water is not furnished. Also, flat type work leads allow quick changing of the induction coils. The fixture employed consists of a hopper that is arranged to receive either of the two work-pieces. The steel plates are approximately 7 by 7 inches square by 3/32 inch thick, and are stacked 20 inches high in the hopper.

An indexing conveyor picks one plate at a time from the bottom of the hopper and moves it into position in the work-coil, which heats all four areas of the part. At the end of each heating cycle the plate is automatically removed and restacked at the base of the table while another plate is moved into the heating position. The operator's only function is to keep the loading hopper filled.

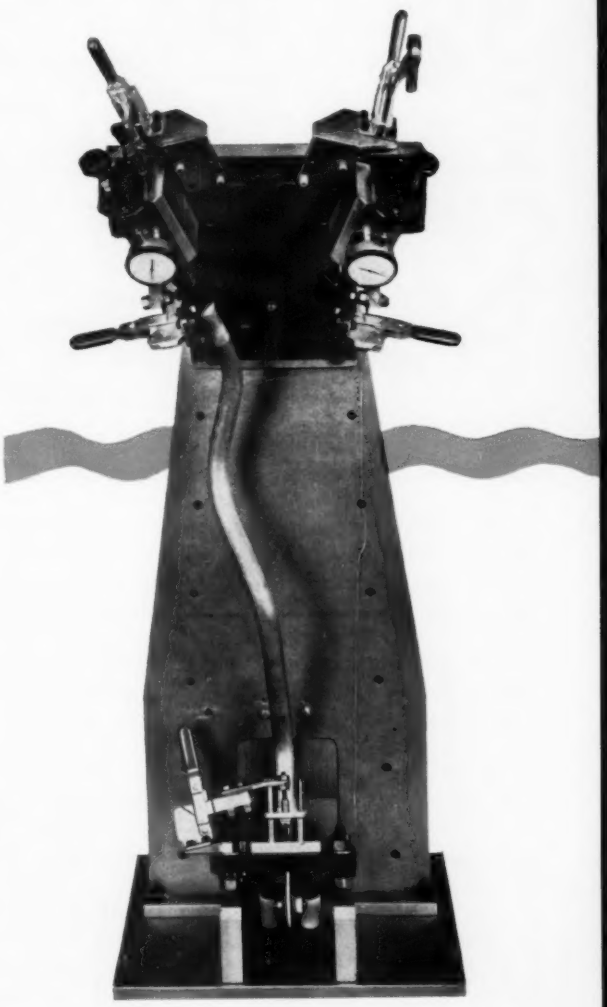


Fig. 6. In this, a second type of fixture, male and female connectors are induction-brazed to each end of aircraft fuel lines. Arrangement allows the handling of either right- or left-hand parts.

Fig. 7. A vertical sliding platen is a feature of these left- and right-hand fixtures for induction brazing of fuel-line assemblies.

These plates are made of SAE 1020 hot-rolled steel, and the heated area on either part, approximately 5 square inches, is raised to a temperature of 1400 degrees F. The generator employed has a 25-kw output and the machine anneals 600 pieces per hour on a twenty-four-hour basis. Among the advantages resulting from the use of this equipment are a uniform product, no scale, an increase in the life of the die in the subsequent forming operation, reduced handling, and safe operating conditions.

Brazing Aircraft and Missile Fuel Lines

Today's jet aircraft and missiles have several thousands of feet of piping for fuel and other auxiliary systems. The brazing of these pipelines is often a problem, since joints have to be fluid-tight and gastight under pressure and/or vacuum. In addition, they have to withstand stresses due to vibration, mechanical shock, and temperature changes. Generally, each joint made must be X-rayed to assure that the brazing alloy penetrates 100 per cent. Induction heating is often used to braze these joints, and fixtures for all types of fuel lines, tubular and flexible, have been designed. A typical setup is seen in Fig. 5.

Joints are first thoroughly cleaned chemically, and flux is applied to all surfaces to be brazed. In this case, a preformed filler-alloy ring is then placed over the tube to rest on the coupling. The assembled joint is put on an expanding mandrel, and an induction coil (partially shown in the illustration) is placed around the work. The mandrel is made of titanium, as this metal cannot be brazed by the filler alloy. It is designed to fit freely inside the tube and is expanded by a cone-shaped member that in turn is drawn into the mandrel by an air cylinder.

The brazing cycle is as follows: The work-coil is energized. The coupling, being closer to the work-coil, is heated first and expands, permitting the alloy to flow into the joint by capillary action. When the joint reaches the temperature at which the alloy has its maximum wetting properties, the air cylinder operates and forces the mandrel against the tube walls; thereby expanding the tube and spreading the alloy uniformly throughout the joint area. At the moment the mandrel expands the tube, the work-coil is de-energized. The joint cools while under pressure. All assemblies are X-rayed to determine whether the alloy penetrated the entire joint.

A completed tube assembly with the tubular joint on the right end is seen in the illustration. The casting brazed on the left end did not require

expansion of the tube, since the difference in the coefficients of expansion of the two materials is sufficient to cause enough pressure between the two members to obtain proper alloy flow.

In making another type of fitting, the fixture and induction-heating coil shown in Fig. 6 are used to braze male and female connectors on each end of a tube. The induction coil has three turns and is designed for low voltage, which eliminates the possibility of electrical shorts or hazard to personnel. The parts are first chemically cleaned; then flux is applied; and a ring of silver-brazing alloy (Handy & Harmon Easy-Flo No. 45) is placed on the joint area. After being assembled and placed onto the fixture, the work-piece is brazed on one end and turned over. Prior to brazing the second end, a ferrule is clamped in the fixture and the lengths of the assembly are carefully measured and set. This assures that the fuel line will be the proper size to fit the engine. The fixture employed can be used to braze both right- and left-hand parts without requiring adjustment.

Similar setups also for brazing right- and left-hand assemblies (Fig. 7) are constructed with a vertical sliding platen, manually operated by a rack and gear. The coils are also designed for low-voltage operation. On some assemblies, the silver filler alloy is allowed to flow through. Then, just before the heat cycle terminates, the operator twists the ferrule or fitting approximately 100 degrees to release any gas trapped in the joint. The whipping action also assures that the silver has thoroughly filled the entire joint area. Another method often employed for the same purpose is to install a vibrator which is energized before termination of the heat cycle and de-energized just prior to the solidification of the brazing alloy. If the vibrator cycle is not properly timed, a crystallized joint will result.

Portable induction-heating units are used by many airplane and missile manufacturers for brazing fuel lines. Flexible leads extend 20 to 60 feet from the equipment to make it possible to bring the induction-heating coils to the work. Where the work-pieces are large, cumbersome, unwieldy, or immovable, mobility of the work-coils is a desirable feature.

At North American Aviation's Los Angeles plant, Ther-Monic remote-operated portable generators with coaxial cables 50 feet long are used to braze fuel lines in B-70 bombers which require 19,000 feet of fuel-tight fusion-welded lines. These dual-output portable generators (heading illustration) make it possible to bring the heating coils to the work inside the aircraft. The generator, which remains outside the aircraft, can operate without a water connection.

Another induction-heating application (Fig. 8) involves the brazing of connectors for flexible lines for planes and missiles. A turntable accommodates one part on the fixture. The second part is installed on the turntable simply by removing the wing-nut and replacing it with the nut-assembled part shown in the foreground of the illustration.

In this case, three rings of a brazing alloy are first melted on the connector to prevent wicking of the silver solder up the flexible tube. If the three rings and flexible tube were to be assembled and heated, the movement of the flexible tube would advance the filler alloy through and up the braiding. Since the tube must be flexible at a point 1/16 inch from the connector, preflowing the filler alloy on the connector allows the tube to be brazed with a minimum of moving.

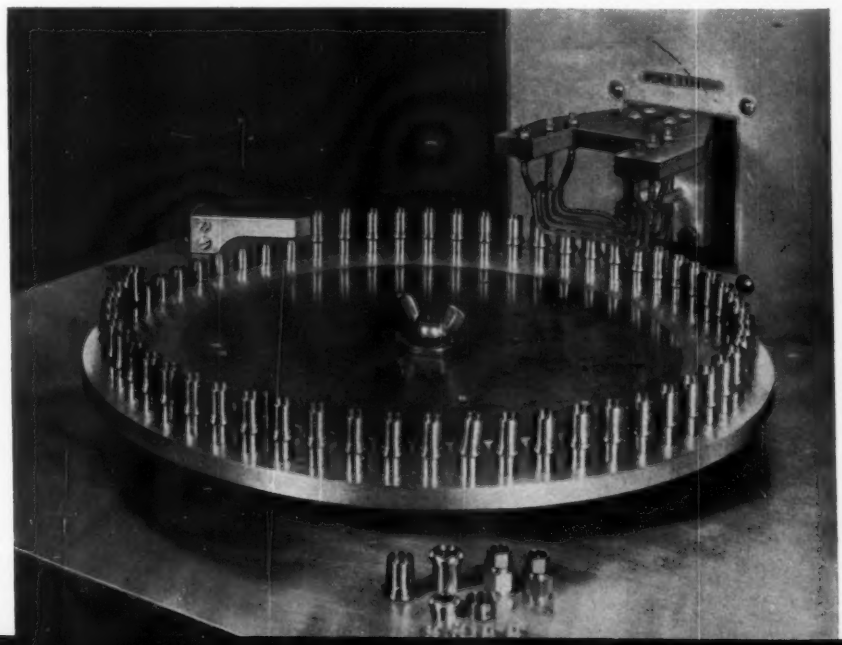


Fig. 8. Turntable fixture for preflowing filler alloy on connectors for flexible lines. This operation prevents wicking of filler metal through and up the braiding when flexible tube is brazed to the connector fitting.

die-casting defects

some causes

some remedies

When a shop encounters defects in its die castings, either at the outset of a run or after continued satisfactory production, the reason often appears elusive. Yet the problem must be met head-on. Although few such cases can be accurately diagnosed from a distance, there are a number of factors—some obvious, others not so obvious—that may prove to be the underlying cause

T. P. BARBICANE

Fig. 1. To effectively finish the cavity surface of a die it should be brought first to a high polish, then retreated to obtain a matte effect. Here, cavity inserts are vapor-blasted with a fine grit to impart the desired finish.

A MAJORITY of the troubles that beset the die caster are concerned with surface finish and solidity, both of which are affected by the flow of metal in the die cavity. Flow, in turn, is governed in part by the nature of the cavity surface, so that, ultimately, it is this factor which plays the greatest role in controlling the quality of the castings produced. If, for example, tool marks are left in the impression, they will be reproduced faithfully on the die casting. Even if tool marks can be tolerated on hidden or unimportant surfaces, they may still have an adverse effect on the general quality of the casting.

Tool marks on surfaces parallel to the direction of draw frequently result in distorted or hot-torn castings. Even if twists or tears do not actually occur, the stresses set up during the impeded ejection stroke often weaken the casting and shorten its effective service life. If castings are easy to eject they can be produced rapidly, the general level of finish is improved and internal stresses are eliminated.

As is generally known, cavity blemishes tend to multiply. Once an operator begins to have trouble in removing castings from a die, his efforts to extract them almost always cause burrs at the cavity edges. Conversely, with a die that permits smooth and fast ejection, the operator need only apply an air blast or lubricant spray.

Lubricants or release agents help to maintain a well-finished cavity in good condition, but they are not a substitute for bench work on the die. Spraying with a heavy lubricant will not eliminate score marks where the cavity edge is peened over and, furthermore, excessive lubrication will introduce additional troubles. Local application of viscous lubricants around drag areas, in particular, is ineffective. The flow of metal invariably washes the material away from the surface to which it was applied, dispersing it throughout the cavity and, frequently, throughout the casting.

If the cavity has been finished to a high polish, little lubricant will remain where it was applied because the pressure of the metal against the cavity surface will squeeze out the lubricant. If the cavity has not been polished, or if it has been grit-blasted after polishing, some of the release agent will be retained by the surface and prevent minute irregularities from being reproduced on the casting. The casting is then easier to eject.

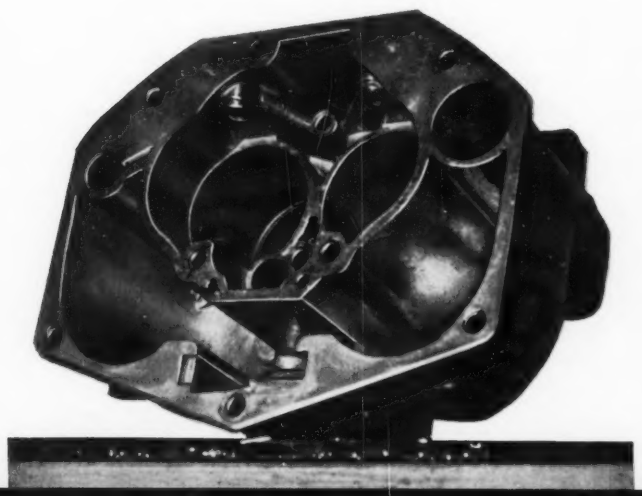
A Recommended Procedure for Finishing Dies

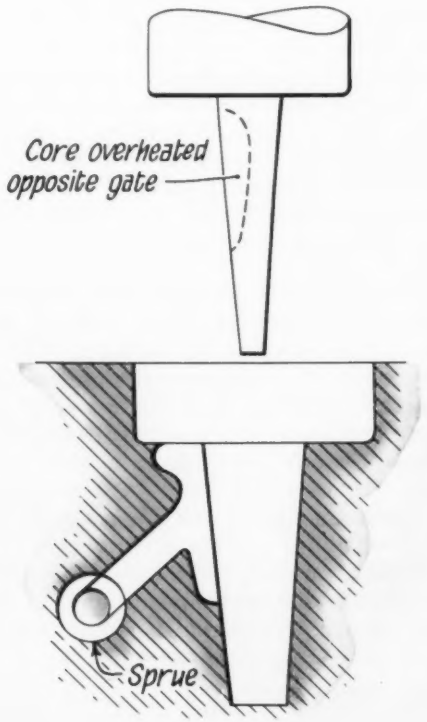
The most effective finishing procedure for a die-cavity surface is to bring it initially to a high polish, similar to that required for an injection mold, to insure that all tool marks have been removed. This is followed by wet blasting of the surface with fine grit (Fig. 1) to obtain an overall matte effect. Cavities sunk by spark erosion, however, already have a satisfactory finish and, because the electrode moves in the direction of ejection and stripping, are free from undercuts and other drag-causing formations.

If the die is available for tryout before hardening, it should be treated with great care to avoid forming burrs and undercuts. The last casting

Fig. 2. (Below) Although the use of lubricant in large quantities should normally be avoided in die-casting production, there are exceptions. For complex castings having minimum draft, a release agent is needed to assure ejection without distortion.

Fig. 3. (Right) If slender cores, such as this one, become overheated, they can be effectively cooled only by spraying with lubricant between shots.





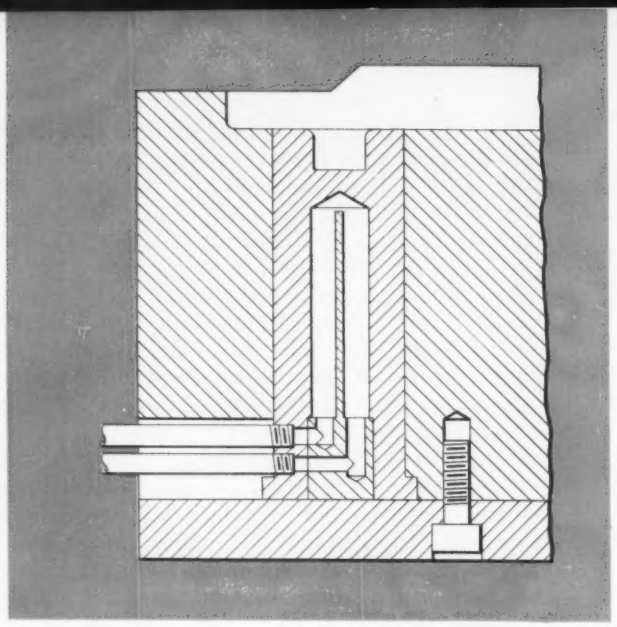


Fig. 4. Sinks opposite a boss or rib can best be eliminated by localized cooling. Cartridge cooling, as shown, will prevent overheating around isolated bosses.

produced should be sent to the toolroom with the die, and every area where binding is suspected should be polished prior to hardening. This is the stage at which economy in bench work can reduce the potential productivity of the tool by thousands of castings. The longer the anticipated run, the more important it is that every effort be made at the preproduction stage to eliminate minute impediments to easy stripping and ejection.

As a check on distortion, the die should be assembled and given a second trial after hardening. It is common practice to place the tool in production if it proves satisfactory at this stage, but it is preferable to strip it down and lightly blast the cavity surfaces, and then to subject the cores and cavity inserts to a second tempering treatment for improved resistance to thermal shock. In some shops, controlled oxidation is allowed to take place during this final treatment. Where tools are surface-conditioned, this treatment takes the place of both retempering and curing. However, because surface conditioning involves a salt-bath treatment, it is necessary to repolish the cavity and core surfaces to remove the loosely adherent deposit.

Dies prepared in this manner are more likely to operate at their estimated production rates from the start, and to improve in ease and smoothness of working as they become properly run in. If this preliminary work on the tool is neglected, the potential level of production might not be attained and frequent delays might be encountered for minor rectifications. It is recognized in most shops that die materials and, to some extent, construction methods must be chosen according to the productive life required of the die. The corollary that more extensive and painstaking bench work is necessary on dies that are scheduled to produce 250,000 or 500,000 die castings is often ignored.

Release Agents and Their Application

Castings are often said to be "difficult" when, in fact, the dies have obvious faults of construction, design, or thermal balance. One remedy frequently resorted to is to use a larger quantity of a heavier and more "loaded," or pigmented, die lubricant, although the application of large quantities of lubricant is always deleterious in die-casting production.

This does not imply that die lubricants—even the heavier and highly loaded grades—can be dispensed with entirely. There are die castings with such unfavorable features from the standpoint of production, as in the example shown in Fig. 2, that only with the regular and frequent application of a graphite or a flake-aluminum compound can they be withdrawn from the die without distortion. Most zinc-alloy die castings, however, can be produced without applying a release agent to either the core or the cavity surfaces. Only such mechanical features of the dies as the core-slides and ejectors require regular lubrication. Many aluminum die castings, on the other hand, are easier to eject if a release agent is lightly applied at least on core surfaces. Desirability of such application must be considered apart from the lubrication of moving die parts.

An analysis of shop practice shows that neither lubrication nor release accounts for the widespread use of excessive quantities of these compounds. To a large extent they are applied in order to reduce the surface temperature of the dies. It is a legitimate practice to spray core tips, as shown in Fig. 3, that cannot be cooled in any other way, but a lavish application of lubricant to the cavity surface as a whole is rarely justified. If the general die temperature must be lowered, it can be done by less expensive means.

Die lubricants consist either of inert material carried by a volatile medium, or of high-melting-point oils and waxes dissolved in a more volatile liquid. This latter group includes the silicones. Any lubricant or release agent which is correctly

Fig. 5. Surfaces parallel to the direction of die closing must be highly finished to avoid drag, but end surfaces of cores may be left in a rough condition to control metal flow in thin sections. Such core surfaces have been reproduced on this casting.

applied leaves a film of the active agent on the die surface, the volatile carrier having evaporated before the next injection of metal. In fact, the vapor should be entirely dispersed before the die closes for the next shot. If a liquid film is left on the die surface it is volatilized as the metal enters, and the vapors create a back pressure that slows injection. In addition, these vapors become trapped in the casting.

The solid film that remains should be thin and even. This can best be insured by using a large volume of the volatile medium, and applying the solution or suspension with a gun that produces a fine, mist-like spray.

One of the disadvantages of existing methods of using die lubricants is that although several different functions must be served, it is not practicable to make an operator responsible for applying more than two different compounds. One of these must be a plunger lubricant—the other must, therefore, serve as a core and ejector lubricant, a release agent, and a heat transfer medium. As ejector seizure is the trouble that first occurs if lubrication is inadequate, the second compound is usually a heavy lubricant, the release properties of which are incidental. If the die has hot spots, consumption of this compound is often high.

Advantages of Automatic Lubrication

Better use can be made of available compounds if plunger and ejector lubrication is carried out automatically. Various companies in this country and Europe manufacture equipment for this purpose. Ejectors present no problem, since any multiple-point oiling system will handle graphitic lubricants in the viscosities generally used, and effective application of heavy plunger greases can be achieved mechanically. It has been estimated by a company supplying lubricants that conversion to automatic application reduces plunger-grease consumption by 50 per cent and enables better die castings to be produced in a shorter cycle time. It is also well-established that the life of plunger tips and shot sleeves can thus be greatly extended.

Automatic ejector lubrication is best performed separately from the application of release agents, and the most straightforward method is to spray the ejectors from the rear of the die-block. This can often be done effectively by two nozzles at most, cam-operated valves being employed to provide a burst of spray as the ejector half of the die is drawn back after casting. The oil mist is directed high into the ejector box so that it falls back on the individual pins.

One advantage of automatic ejector lubrication, apart from greater reliability, is that it enables a light release agent to be used on the cores. If the die is particularly subject to hot spots, a water-diluted spray can be employed. Such a spray acts primarily as a means of heat dissipation, but leaves a film on the surface. If a spray of this type is used in the absence of a separate lubricating system for the ejectors, however, galling and failure will result.

In addition to cooling the die while they are being applied, all lubricants and release agents have, to some extent, an insulating effect. For this reason, the application of some compounds—for example, those containing talc—has a definite effect on the incidence of surface blemishes where the thermal balance of a die is unsatisfactory. Obviously, however, such treatment is only a palliative, and although the use of these compounds may slightly reduce the percentage of scrapped castings, they have an adverse effect on the operation of the die because the residues block vents and abrade moving parts. The real remedy is to correct the cooling and thus eliminate local overheating of the die.

This applies to many defects encountered in production. Die lubricants offer a temporary means of overcoming them, but the proper course is to alter the die so that they do not recur. Any

operation for which the consumption of release agent is above average should be carefully scrutinized. With zinc, in particular, little lubricant is usually needed. Therefore, any sudden increase in lubricant consumption almost certainly indicates worn ejector housings, damage to core surfaces, or "soldering."

If a die for casting zinc is in good operating condition, the most that is needed—apart from routine ejector lubrication—is a short burst from a spray gun of a well-diluted release agent into the sprue hole before each shot. This treatment is only necessary, moreover, on large castings of thin section and of a decorative character. Sometimes it is preferable to apply the release agent locally at the base of the sprue pin or in the main runner.

Lubricants are often applied to prevent sinks in the surfaces of thin zinc-alloy parts, and usually have some effect because they drastically modify injection. In the first place, they chill the surface at the site of the fault, with the result that a thicker shell is formed. Second, they may leave evaporable residues that volatilize as the metal runs in, with the result that filling is slowed and sluggish turbulence occurs. It is likely that the large inclusion of air which caused the sink at the original site is broken up and moved elsewhere. If a sink occurs opposite a boss or rib, the effect of the spray is merely to move the shrinkage from the surface to the inside, where it may cause trouble in drilling. To eliminate it altogether, local cooling of the boss is required, and this may be accomplished in the manner indicated in Fig. 4.

The opposite fault—short runs or seams—may also be corrected or reduced by spraying lubricant into the sprue hole. More lubricant is needed in this event, as it is required to form an insulating layer as the metal reaches the distant portions of the impression. This expedient should only be used at the beginning of a shift, when it may be necessary to be sure that the metal fills the impression before the die has reached proper working temperature. If the blemishes do not disappear after approximately six shots, the real need is for additional overflows to keep the die hot near the locations of the seams.

A sudden onset of either fault when the die has previously operated satisfactorily usually implies that there has been some change in the water cooling. Either a line has been blocked or, if the fault is due to chilling, too much water is flowing.

Sometimes, however, the sudden appearance of a blemish is evidence of a more radical trouble, such as loss of hydraulic pressure, and faults of this type are sometimes experienced with a die after it has undergone routine maintenance. The explanation may be that a water-line is plugged, or that the water-lines have been incorrectly connected. If a new sprue pin or bushing has been fitted, a check should be made to determine whether the sprue section has been altered so as to choke the flow. When a die that has given good results on one machine will not operate satisfactorily on another of the same type and capacity, the fault is not usually in the tool but is more likely the result of differences in the plunger and sleeve assembly.

On a machine for casting zinc, the trouble may be due either to difference in valve settings or to a worn plunger on one machine. A small leak through a blow-hole in the gooseneck can also affect the injection. On a cold-chamber machine, the fault is more likely to result from poor alignment of the plunger and sleeve on one of the machines, or possibly from a scored plunger tip. If one machine is equipped for automatic lubrication and the other is not, there may be a considerable difference in the friction losses during the plunger stroke, and consequently in casting quality.

Blemishes in thin castings, both of zinc and aluminum, often occur because a very shallow

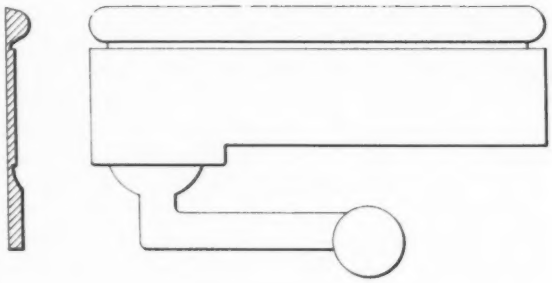


Fig. 6. Design of overflow wells should be carefully considered for thin, flat castings. In this case, metal directed into the end of a deep overflow may outflank that moving along the main cavity, leading to the formation of air locks.

gate has been provided to facilitate trimming. The metal is then laid down as a shell on one surface—the convex surface, in the case of a contoured part—and during the filling of the remaining space the flow is turbulent. Where air is trapped the surface sinks, but will subsequently rise in a blister if the casting is heated. The remedy is to provide a deeper gate, of at least half the thickness of the section, so that the metal stream fills the whole space between the die walls and advances along an unbroken expanding front.

Finish on End Surfaces of Cores

Although tool marks on cavity surfaces parallel to the direction of stripping must be completely polished out, it is sometimes an advantage not to finish the end surfaces of large cores which are at right angles to the stripping direction. If cutter marks are left on these surfaces, the flow of metal over them is slowed down and steadied. Such marks have been reproduced on the casting shown in Fig. 5. Due to these marks, die temperature becomes a less critical factor. This is attributable to a reduced tendency for the metal to leave the surface of the die and trap a pocket of air when the tool becomes heated.

If the rough-machined finish is not acceptable, some control of flow can be obtained by stippling or coarse grit blasting. The latter gives an even finish, acceptable for almost any component, and stabilizes flow sufficiently to delay the appearance of blemishes on the opposite surface. Ribbing on the underside of the component also offers a means of stabilizing and directing flow. Shallow ribs located across the direction of metal flow will help reduce blemishes, but if deep ribs are needed for structural strength the metal stream should follow along them.

Design of Overflow Wells

Defects in thin, flat castings can result from badly proportioned overflow wells. Long, narrow overflows which are close to the edges of castings and gated throughout their length, as in Fig. 6, are a common cause of trouble. If the strongest metal flow is directed into one end of the overflow well, it is likely to fill more rapidly than the thin-section wall. Metal may then feed back into the cavity ahead of the main stream, hindering the

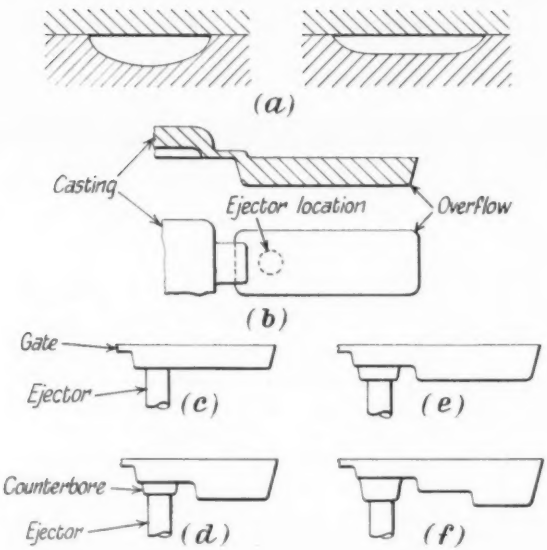


Fig. 7. Overflow sections seen at (a) are ineffective, while the form at (b) should be accepted as standard. Successive stages for increasing overflow volume are shown in (c) through (f).

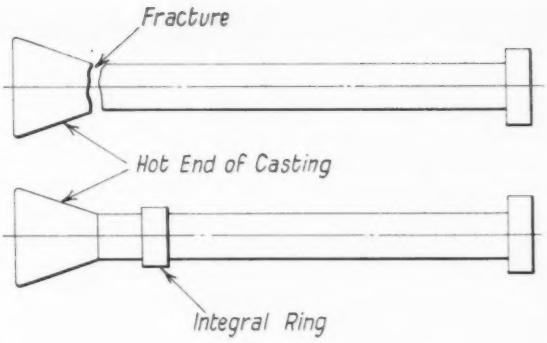


Fig. 8. Fracture at the joint line between thin and thick sections can sometimes be prevented by limiting pre-ejection shrinkage. In this instance, an integral ring near the end of the stem avoided unwanted stress concentration.

escape of air and the flushing of sluggish metal.

To determine whether this action is taking place (on a cold-chamber machine), a short shot may be poured. If it is found that the overflow is filling in advance of the cavity, the remedy is to weld up and recut the well. For best results, a series of separate pockets should be provided along the cavity edge. It is preferable to first gate only the pockets nearest to the site of the defect. If the position of the blemish is to be moved without completely eliminating it, more of the pockets can be gated and, if necessary, extended outward to increase their volumes.

It is desirable to provide only milled pockets for overflow wells, as shown at *a* in Fig. 7. To insure a free flow, the minimum depth of the pocket should be 50 per cent greater than the wall thickness of the casting at the gate location, as indicated at *b*, and the width should be three to five times the depth. Initially, the length may be twice the width. If the volume proves insufficient, the first alteration should be to double the depth of the farthest half of the well. Subsequent increases should be made step by step, in the manner depicted in the diagrams *c* to *f*, to avoid too great a concentration of heat near the edge of the casting and to minimize difficulties in providing clearance on trimming tools.

Ejectors should be provided for most overflows to facilitate venting as well as to eliminate sticking. As the volume is increased, the ejector should be shortened to leave a projecting stud. This modification is necessary whether the overflow is cut in the cavity half or the ejector half.

When Cracking Occurs

Cracking occurs wherever a casting is unduly stressed during natural contraction, but is most marked when working with short freezing-range alloys or commercially pure aluminum. There are two approaches to this problem. Restraining features may be incorporated in the die to prevent tension across the localized area where cracking occurs, or one of the anchoring faces that is impeding free contraction may be eliminated. For example, fracture of a dumbbell-shaped piece, which regularly occurred at the junction between the thin stem and thick head, was prevented by adding a ring on the stem as seen in Fig. 8. This avoided stress concentration in the critical area. If overstressing is marginal, with stress cracks occurring in only a small percentage of the parts, it is often sufficient to add small lugs, having ejectors bearing on them, near the thick section.

To avoid constraint, it may be necessary to reverse the normal position of the cavity in the die and to sink projecting lugs in the cover half. This arrangement enables contraction to take place freely as soon as the die opens. If the constraint is caused by small cores which pass through the casting, they can be mounted on a separate plate and pulled by rack and pinion, even before the die is opened if necessary. Invariably, the operator should work as fast as possible with a hot die and pull all cores at the earliest possible moment.

Core temperature is critical when casting the

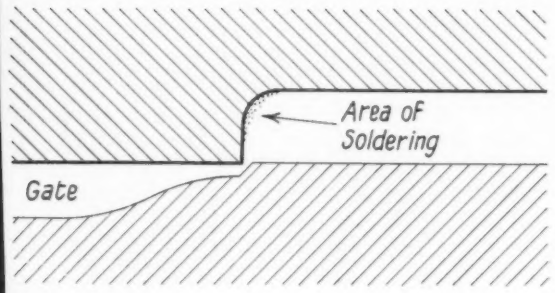


Fig. 9. Soldering may occur if the metal is atomized as it passes through the gate. This build-up often starts on the back surfaces of the cavity near the gate.

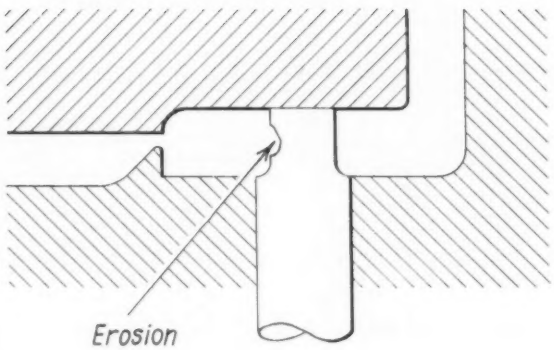


Fig. 10. Erosion results when molten metal strikes an area of the die at nearly a right angle, washing away particles of surface metal. If erosion takes place on a core as shown, an undercut will eventually develop.

hot-short alloys; for if local overheating occurs, a crack develops due to the pull of the more rapidly chilling metal. On the other hand, if the cores are too cold the metal quickly chills around them, then fractures as they expand. it is desirable, therefore, not to spray lubricant copiously on the cores in such cases, but merely to apply a short burst of spray at the base of each core.

Soldering and Erosion

Soldering is nearly always associated with the use of knife-edge gates and high injection pressures. Although it is sometimes stated that the die-cast metal "alloys" with the die surface, there is no evidence—at least with aluminum—to support this.

Soldering begins when metal is sprayed into the cavity as fine globules which adhere to the surface with a strong mechanical bond. In this way, an adherent rough-surfaced layer is built up in the same manner as a sprayed-metal protective coating. The fault often occurs first on back surfaces of the impression not in line with the metal stream, and frequently at a point near the gate, as indicated in Fig. 9. Regular application of a release agent is fairly effective in preventing soldering (but not erosion, with which the former fault is sometimes confused).

Erosion occurs where the stream of molten metal impinges on the die or core at right angles, or nearly at right angles, to the surface. Under these conditions metal is actually washed away from the surface by the stream. Since the material is eroded irregularly, the effect is to produce a rough, almost granular surface on the casting similar to that caused by soldering. If the erosion occurs on a core, however, the continued washing action produces an undercut (Fig. 10) and causes a heavy drag on the casting.

No amount of release agent or other lubricant will cure this fault. The only real remedy is to relocate the gate, or enlarge it and reduce injection pressure. If these are not applicable, it is helpful to mount the cores so that they can be rotated easily in the die, and to turn them at intervals to present fresh surfaces to the stream. A large core having considerable engraved detail —which would be expensive to replace—can be constructed with a shrunk-on external sleeve that can be discarded when badly eroded. If cores subject to erosion are small and simple, it is usually preferable to replace them on a regular preventive-maintenance schedule.

Metal-Handling Practice

Poor metal-handling practice may be responsible for the production of a considerable proportion of substandard die castings. With aluminum alloys, high scrap rates on large, thin-walled die castings can sometimes be traced to throwing the faulty castings back into the holding furnace.

This practice is sometimes followed even where modern types of low-temperature induction furnaces are provided, with the result that the inherent advantages of this type of equipment are obscured. The scrap castings are covered with an oxide film, and may contain substantial amounts of the release agent. Consequently, impurities are released into the melt, but not dispersed, and are ladled out again to cause further imperfections. All scrap metal should be melted in breakdown furnaces and fluxed before being cast into ingots.

With older types of melting equipment, inadequate temperature control is the main factor affecting part quality. Steady die conditions cannot be maintained if the temperature in the holding furnace varies. Frequently, the casting temperature rises steadily as the level of the metal in the holding furnace falls, and the operator gradually slows the casting cycle to avoid overheating the die. When the pot is recharged, even with molten metal, there is an immediate drop in temperature and casting conditions are again upset.

The general tendency, when operators are left to their own devices, is to work with overheated metal and to slow the rate of production accordingly. Castings of the best quality, on the other hand, result from working with cool metal at a sufficiently rapid rate to keep the die hot.

Heating the Dies

To some extent, the lack of balance in the temperature of a die-casting die can be overcome by providing a large total volume of overflows, all of which help to heat the outlying parts of the die. However, severe local cooling—necessary to permit high production rates—removes more heat from the die at points which do not need cooling than can possibly be restored by overflows. In the past, the usual practice has been to apply gas flames to the outside of the die to maintain the temperature at points remote from the sprue or slug. As a means of heating specified areas, this procedure leaves much to be desired. A more controllable system makes use of refractory blocks in which heating elements have been embedded. These blocks—which are either built into the die or clamped to its outside faces—are effective for very localized heating, but tend to soak up oil.

A method of wider utility involves the use of infrared heaters set away from the sides of the die and radiating inward. These heaters have a high thermal rating and can be used to preheat a tool in readiness for operation, as well as to main-

tain an even working temperature. For preheating, however, it is best to augment the fixed heaters with a two-sided radiator hung in the open die.

With the fixed side heaters and movable face heaters all in operation, a die can be raised to operating temperature in less than an hour. Paradoxical as it may seem, the great advantage of infrared heating in this manner is that it permits more cooling water to be passed through the die. Because heat is diffusing inward from the outside surfaces of the die-blocks, it is possible to extract much more heat from the hot spots in the cavity without chilling the remainder of the die. Closer control can be achieved in this way, and die temperature can be held in balance at a higher level than would otherwise be possible. With a correctly designed infrared face heater, the whole of each die-block can be raised from room temperature to 250 degrees C. without establishing, at any time, a gradient of more than 30 degrees C. between any two points.

Infrared heating, although valuable to the shop that is already operating at a high level of efficiency, will not enable poorly trained or inadequately supervised operators to suddenly produce a high percentage of sound die castings. With the whole casting cycle already under control, and a scrap rate of perhaps 4 per cent, radiant die heating offers a means of further improvement. If, however, regular production yields from 7 to 10 per cent of scrap, there are more fundamental troubles to be overcome before the refinements of die heating need be considered.

Changes in Work Quality

Slow deterioration of casting quality sometimes occurs with long-run jobs. Often the only trouble is that the die is becoming choked with lubricant residues, and it suffices to strip it down, carry out a routine check for cavity condition and wear on ejectors, and return it to production.

Another possible cause of falling quality is lowered efficiency of the machine hydraulic system. A reduction in efficiency may result from sticking valves or from air trapped in the hydraulic system, which results in spongy and slow operation. Air can leak in at loose joints on suction lines, and may be carried in as foam if the return pipe feeds in at the top of the oil tank. Extension of the pipe to the bottom of the tank, checking of joints, and, if necessary, addition of an antifoaming agent are obvious precautions.

The experienced supervisor invariably follows a regular routine when investigating a decline in quality. First, the machine is observed through three or four cycles without attention to the castings. All gages and dials are checked to ascertain whether there is a fault in any of the services—hydraulic, electric, gas, and water. The next step is to check metal temperature—visually, at first, and then, if necessary, with a portable pyrometer. Subsequently, water outlets from the die are examined and the water temperature is tested by a touch of the hand at each outlet pipe. Even if there is some obvious fault the procedure is carried through because actual malfunctions, such as metal cutout, need to be interpreted in relation to all other aspects of the casting cycle.

If all the services appear to be functioning satisfactorily it becomes necessary to check the mechanical operation of the machine. The plunger stroke should be carefully studied. Shudder, or a tendency to "hang up" just before the end of the stroke, may indicate plunger wear and galling or, possibly, a sticking valve in the injection-head circuit. If the injection system is satisfactory, it is possible that the operator is pausing too long between pouring and injecting, permitting the metal to become chilled.

Investigation of Die Condition

If the defects are mechanical—scuffs and scores rather than sinks and voids—the state of the die itself must be checked. Small burrs at the edge of the cavity can cause severe scoring where there is little draft. If the cavity is well tapered, yet score marks are visible over a considerable distance down the sides of the casting, the fault may be wear on the dowel and register surfaces. Alternatively, the clamps on one die member may have become slack, with the result that the tool is not opening squarely.

Drags on a core, not readily attributable to visible undercuts, may also result from lack of alignment. In this case, the trouble is usually due to the ejector plate not pushing the casting off squarely. If the die has moving side cores it is necessary to ascertain that they are being pulled clear of both the casting and the flash before ejection starts.

Because dies vary greatly, both in complexity and mode of operation, it is impractical to detail all points to be checked when searching for the causes of casting defects. The main requirement is that a logical sequence for any particular die be formulated, and that it then be carried through systematically. ■

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Tiny precision bearings boost

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guidance system reliability

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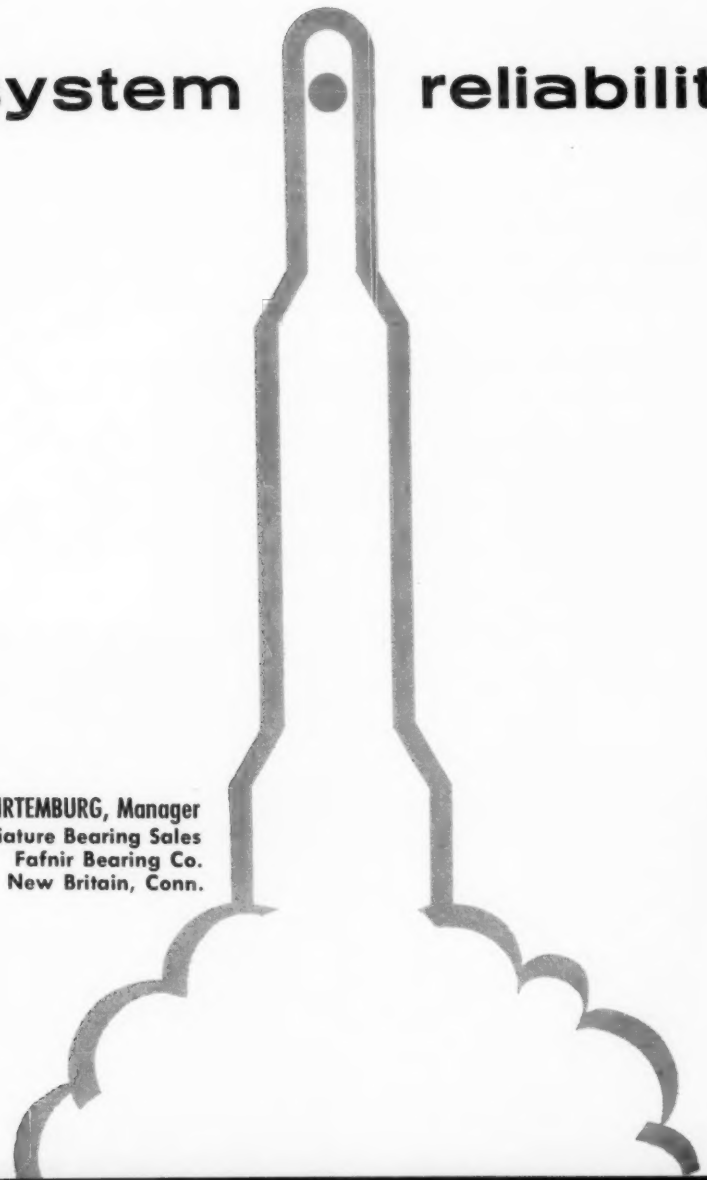


RALPH O. WIRTEMBURG, Manager
Instrument & Miniature Bearing Sales
Fafnir Bearing Co.
New Britain, Conn.

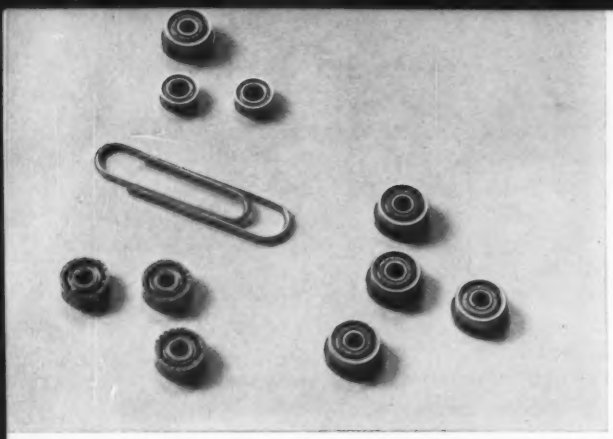


Fig. 1. Instrument precision miniature ball bearings shown alongside a paper clip resemble their large counterparts but are accurate to millionths of an inch.

Take the antifriction ball bearings out of aircraft and missiles and it is doubtful that their performance will improve. Ball bearings have influenced aircraft control and guidance design and reliability. Similarly, the concept of reliability engineering has produced major changes in precision miniature bearings and methods by which they are made

THE "plain Jane" ball bearing, once regarded as a simple, though necessary, piece of "hardware," as standardized as the wheel it served, has joined the ranks of modern scientific glamor components because of the high-precision requirements of instruments used in a wide range of end products from data-processing computers to moon missiles.

Where tolerances were once expressed in thousandths of an inch, requiring check points no more exacting than visual tests and mechanical gages, today's miniature bearings must meet tolerances to within millionths of an inch, utilizing processes and machines of microscopic accuracy in both production and testing stages, Fig. 1. Precision miniature bearings are made by a division at the Fafnir Bearing Co., New Britain, Conn.

Whether large or miniature, antifriction bearings are strictly functional. Progress in the art of making instrument ball bearings has been more closely oriented to the development of all kinds of air and space vehicles than, perhaps, to any other class of components over the past thirty years. Instrument precision bearings are deceptively simple in appearance. Though smaller, in many cases, than the balance wheel in a

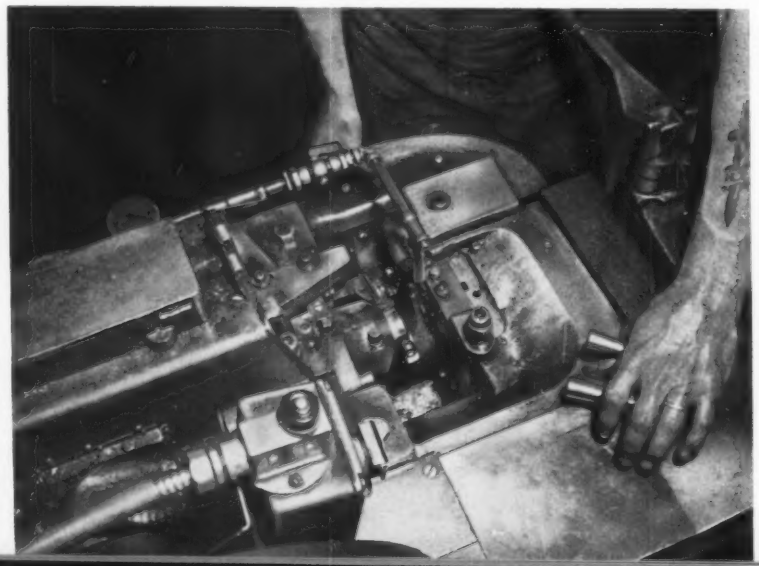


Fig. 2. Process of making a ball starts on a boltheader, with wire as the original stock.

fine watch, they look, to the naked eye, little different from the conventional size of bearing.

Precision bearings of the type produced by Fafnir are, in general, comprised of three basic components—the ball assembly (with some form or retainer), an outer race, and an inner race. To these may be added a seal or shield for protecting the bearing against the entry of outside contaminants. Each of these components is processed through an intricate sequence of machining, grinding, honing, cleaning, and other operations.

The balls roll in a pair of tracks or raceways ground into the inner diameter of the outer ring and the outer diameter of the inner ring. These raceways constitute the most critical areas of a ball-bearing assembly. No pains are spared in the attempt to achieve perfect smoothness and correct contour of these areas.

In the manufacture of all ball bearings, and especially those in the precision miniature field, roundness and surface finish are of ultimate concern. The approach to perfection in these departments is, in the main, the measure of quality. Precision bearings must approximate perfection to an infinite degree.

The initial stages in the production of miniature bearings are much the same as those for more conventional types. Balls are cold-headed from round 440-C stainless-steel wire at high speed, Fig. 2, by equipment built by National Machinery Co., Tiffin, Ohio. These are made in a plant maintained exclusively for ball manufacture and use facilities set apart for miniature balls.

Filing or grinding in automatic machines removes the excess flash from the balls, achieving roundness within a few thousandths of an inch. The balls are next heat-treated, Fig. 3, to achieve the desired physical characteristics. Then, in the hardened state they go through standard grinding and lapping processes. All types of balls are tested for size uniformity, sphericity, and visual surface appearance. Also, they are sonically tested for the amount of noise they make when in operation.

In the case of miniature balls, additional finish-lapping operations are performed on special machines whose revolving action generates a smooth spherical surface of optimum uniformity. Fine gaging then measures the balls for size variation and roundness to a maximum of a few millionths of an inch.

For scratches and stains, the balls are examined under a binocular microscope at high magnification. For waviness, they are checked on a Wavometer similar to that to be described later in connection with the testing of inner and outer races. Finally, they are returned to the sonic testing room, where they are required to meet still

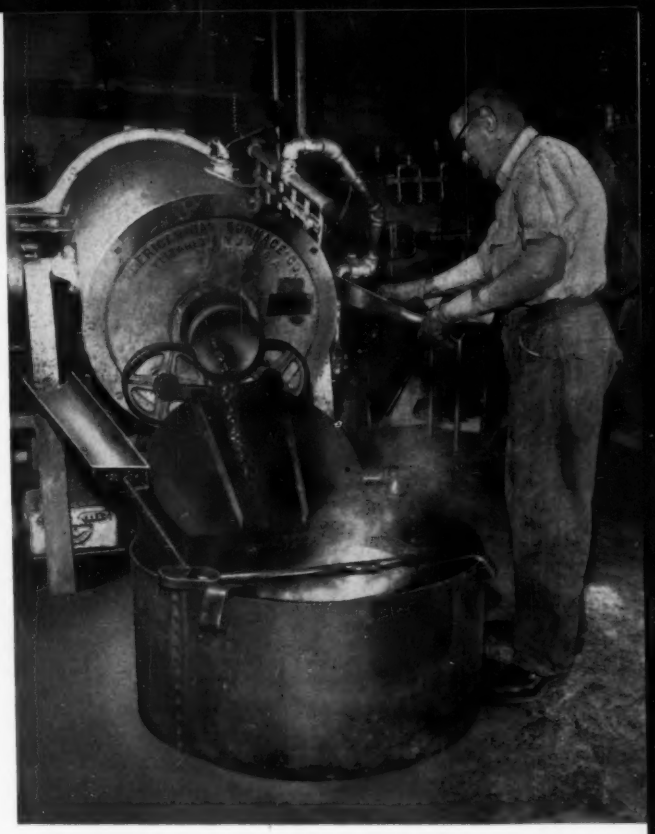


Fig. 3. Heated balls pour into an oil quench from a rotary retort furnace, during heat-treatment.

Fig. 4. Sonic test of inner-raceway ball track is a preliminary step in the manufacture of all precision antifriction bearings.

Fig. 5. Key manufacturing step in making superprecise miniature bearings is the centerless finish grind of the outer ball race on the Bryant Centalign machine.

more stringent tests for quietness. Here the sound-level tolerance is exceptionally low. They are finally ready for assembly with the race components.

Races for miniature bearings, too, begin their manufacturing cycle in the same manner as those for conventional applications except that, like the balls, they are turned on an automatic lathe from vacuum-melted stainless-steel bar stock. After machining, both inner and outer races are heat-treated in dissociated-ammonia, atmosphere-controlled furnaces, then vapor-blasted to ensure a smooth surface, free from discoloration. In the case of certain special and superprecision bearing applications, where exceptionally high temperatures prevail, additional stabilization is obtained by subjecting the rings to deep-freeze conditioning at temperatures down to minus 120 degrees F.

From this point, inner and outer rings go their separate ways until they reach the assembly matching stage. Each ring is subjected to a series of grinding operations, which brings their final internal and external "roundness" to within millionths of an inch. Grinding of the faces, outer diameters, bores, and raceways is followed by meticulous inspection after every stage, Fig. 4. The finish grind of the inner raceway is determined, as to size, by the outer-race diameter.

It is in production equipment for finish sizing and grinding that the effects of reliability engineering are most noticeable. They already look perfect to the unpracticed eye. But it is only the beginning of the processing that qualifies them for instrument application.

Among several types of new equipment is a battery of outer-raceway grinders, Fig. 5, furnished by Bryant Chucking Grinder Co. of Springfield, Vt. These machines are in the company's Centalign race-grinder series. They feature a disc-drive centerless work-head and "packaged," quick-change tooling, Fig. 6. The small contoured grinding wheel is automatically dressed to form by an automatic arrangement. Since the ideal surface speed for grinding hardened steel is in the neighborhood of 5000 sfpm, the wheel-spindle must turn at speeds up to 150,000 rpm. Special alternating-current electric motors are needed to achieve the speed and, similarly, a special alternator to step up the 60-cycle line power supply to a frequency adequate to turn the spindle motor at the needed speed.

This machine's quick-change tooling permits presetting of alternate work-positioning tooling. While one lot of work is being run, the succeeding setup can be made ready for the next order. Miniature races are often so small in size that they cannot be handled by gravity feeds, and furthermore they have so little mass that magnetic devices are impractical. Consequently, all loading and unloading must be mechanical in order to be positive in action. Obviously, these races are too small to be handled with the fingers, Fig. 7.

After grinding, the races are washed in a series of cleaning cycles, including ultrasonics, to remove any fine particles adhering to the metal surfaces.

Finally, the raceways are precision-honed. As noted previously, the raceways of a bearing constitute one of its most critical areas, especially in those operations where low starting torque and extreme quietness of operation are requisites.

To achieve these objectives, Fafnir has de-

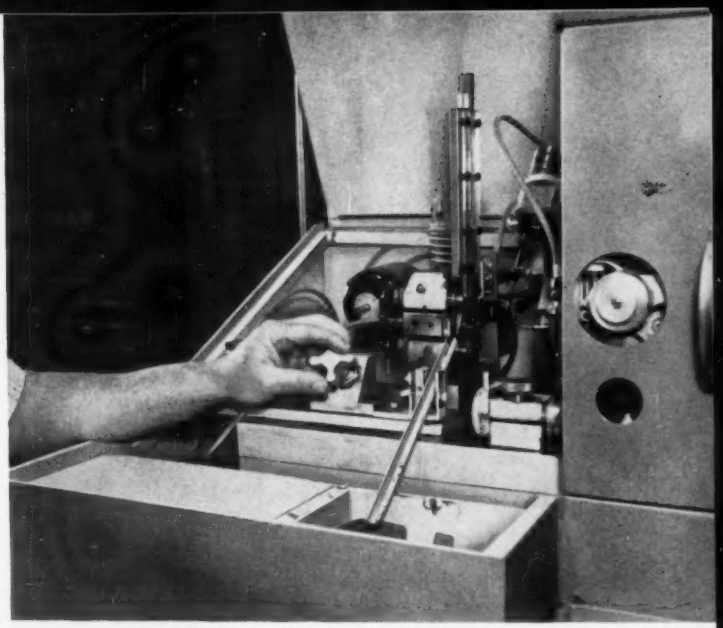


Fig. 6. The tiny races are positioned for final centerless internal contour grind in a demountable quick-change holder. Feed magazine extends vertically.

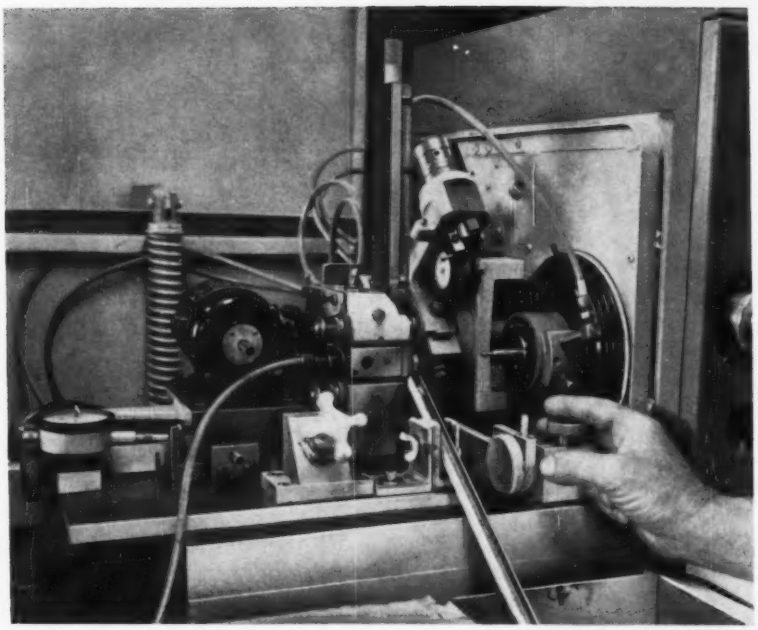


Fig. 7. Finish-grinding wheel on the spindle, above and slightly to the left of the operator's finger, turns at 150,000 rpm to grind at 5000 sfpm. Wheel is automatically dressed to form.

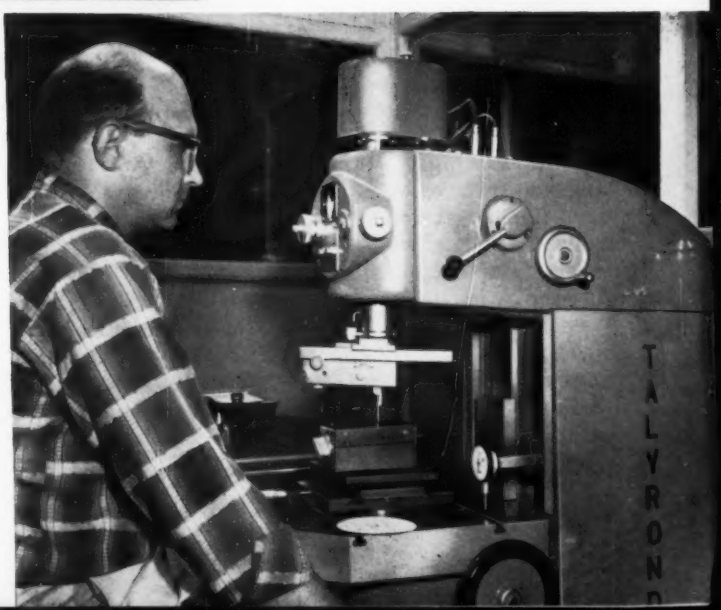


Fig. 8. Roundness of the outer ball-race contour is accurately analyzed and recorded by the Talyrond machine. Out of sight behind the top arm is the chart tracing device.

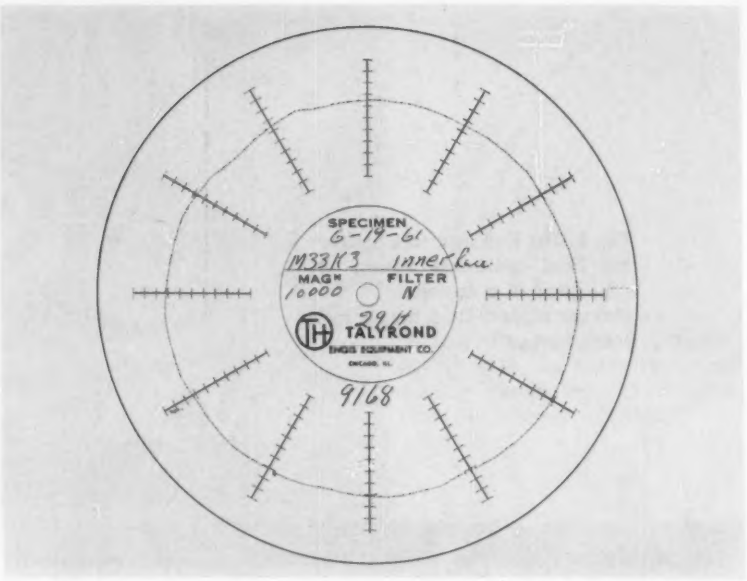


Fig. 9. Radial lines on Talyrond chart represent 10 millionths of an inch, thus each division is 1 millionth of an inch in this chart recording from a typical instrument miniature bearing.

signed its own special honing equipment, which, for certain types of bearings, has now supplanted hand polishing and other methods of eliminating waviness from race surfaces. In general, honing provides better "geometry" of the raceways and a supersmooth surface, where needed. This is the last stage in production of miniature bearings before matching and assembling of all components.

The work-flow pattern in the manufacture of miniature bearings is not, by any means, a straight-line operation. It is constantly being interrupted by testing and inspection, using various special devices ranging all the way from common snap-gages and microscopes to the most delicate electronic equipment.

One of the most helpful of the latter is the Wavometer, made by the Micrometrical Mfg. Co. It is designed to measure waviness on symmetrical surfaces of rotation. Such waviness, which occurs on virtually all metal surfaces, is a common cause of overload, wear, noise, and vibration in antifriction bearings and other rotating parts.

Because of their combination of shallowness and wide spacing, it is impossible to detect most waves on surfaces of rotation such as ball raceways. Rapid and dependable waviness measurements can be made only by means of instruments designed for that specific purpose.

The Wavometer is a fast, dependable shop instrument which gives meter read-out in microinches (millionths of an inch) of the micro-inch rms height of the waves, in two light-wave bands. It also shows on an oscilloscope the general shape and spacing of the waves in either wave band; and it features a loud-speaker that enables the operator to detect deviations from quality by ear.

Use of the Wavometer permits controlled checking of the surface finishes of the races of both inner and outer rings.

The curvature of the outer race is measured on an electronic tracer; the inner raceways by an optical comparator operated by template or radius button, which throws a shadow magnified as large as 50× to reveal the slightest variation in the ball track.

Always and ever, the ultimate standard of bearing configuration is that of perfection in roundness. Perhaps the most useful instrument devised for testing this quality in miniature bearings is the Talyrond (Fig. 8), which draws a picture depicting the degree and variation of roundness of bores, races, rings, and balls subjected to its test. This instrument is simple to manipulate, rotating at a slow speed of 3 rpm, recording its findings on a circular paper chart 4 1/2 inches in diameter, Fig. 9. Thus, a permanent record can be kept of every bearing component tested.

The Talyrond provides magnification at the ratio of 10,000 to 1 and is accurate to about 3 millionths of an inch.

At this stage, a completely new element enters the picture in the manufacture of miniature precision bearings. Concern has been, up to this point, mainly with problems of configuration: i.e., elimination of surface waviness and achievement of perfect roundness, smooth raceways, etc. Now the problem becomes basically one of cleanliness.

Cleanliness is a relative term, but in the company's lexicon it involves precautions that are ex-

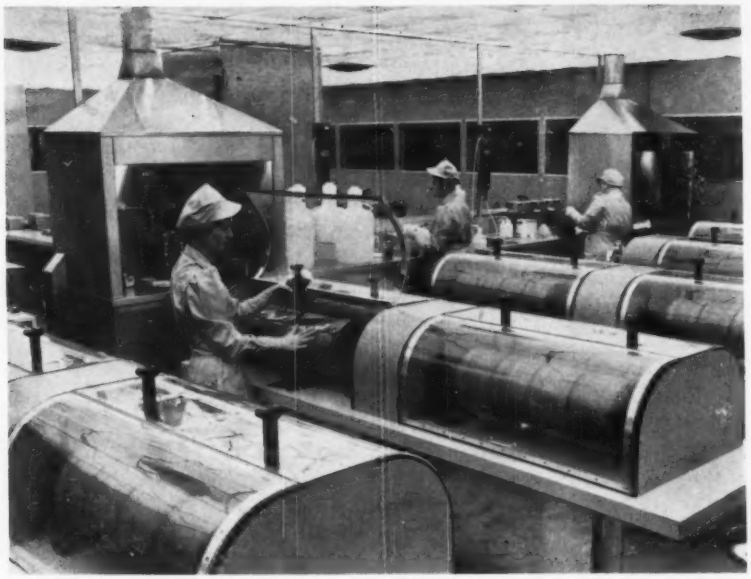


Fig. 10. Clean-room deburring of guidance system miniature bearings is handled by this battery of tumbling machines.

ceeded only by those in the operating room of the best-run hospital.

The final assembly, inspection, and packaging of miniature ball bearings require conditions free from airborne dust and dirt to an extraordinary degree. For added quality assurance, these bearings are subjected to a series of cleaning processes, tests, and other protective measures which guard against any possibility of contamination up to and including the time they are sealed in vials or bags.

For these operations, Fafnir has constructed one of the most effective dust-free "clean-room" assembly and inspection departments in the precision-bearing industry.

The clean-room system at Fafnir is divided into several areas separating each of the concluding stages of bearing production. The air in all of these areas is passed through five filters, including two Precipitrons and one of the Cambridge absolute type, excluding contaminants over 0.2 micron or 0.000008-inch particle size. Temperature and humidity are regulated to preset atmospheric conditions that are monitored by a master control board in the foreman's office area. Entrance of airborne dust is prevented by outward pressurization of the air, increasing in proportion to the requirements of the work done in each area.

The entire department is glass-enclosed. Partitions meet the floor in a curved baseboard to eliminate corners, and thus facilitate cleaning. A vacuum cleaning system is provided with flush bayonet floor outlets to accommodate a long plastice hose that permits coverage to every point by the cleaning devices.

Before entering the area, all personnel must don special lint-free orlon dresses, caps, smocks, trousers or coveralls, and, often, gloves, which are stored in plastic clothes bags in individual lockers. Upon entering an air-lock vestibule, each person is sprayed by an overhead air shower, which is tripped when anyone entering steps on the unavoidable switch mat. "Shining" one's shoes is a must. In the approach vestibule serrated mats scrape shoe bottoms; then automatic cleaners brush the tops, soles, and sides of shoes. Subsequently, two stages of gummed matting remove any remaining dirt from the soles. Hands are washed in a "decontamination" room, then dried under a hot-air drier because no toweling of any nature is allowed in this area.

No pencils—only ball-point pens—or exposed paper are permitted. Routing tickets, etc., made of special lint-free material, are enclosed in glassine envelopes. Air-lock entries are provided for bringing work into and out of the area. All parts-handling equipment, so far as possible, is made of stainless steel, including washing sinks, washing machines, solution-mixing vessels, strainers, and work trays. The tote trays, which carry the bearings through the various stages of assembly, cleaning, and inspection, have rounded corners, and are thoroughly cleaned after every handling.

After assembly, each bearing is demagnetized to free any metal particles remaining from the grinding operation. Then the oil residue is stripped off by three successive dips in a solvent solution, using a separate strainer for each stage.

Bearings are next subjected to a series of tumbling routines in a patented solution to loosen contaminants and to remove microscopic imper-

Fig. 11. "Green room" inside clean room, Fig. 10, has an even more closely conditioned atmosphere where final dimensional controls are imposed.

fections in raceway finishes, as seen in Fig. 10.

Between each tumbling stage, the bearings are rinsed in tap water. After the final rinse, they go through three successive washings in deionized water, after which they are placed immediately under a hot-air blast at 250 degrees F., remaining there until they are completely dry.

A number of other cleaning procedures and devices are used for bearings of varying characteristics. These include ultrasonic cleansing to loosen metal and other particles; and may also include dial washing—consisting of a wash; an air blowoff; a saturation wash and a final air blowoff; and a pressurized spray booth wash using extremely high evaporation-rate solvents.

Bearings requiring prelubrication are fed with a grease gun, using a filtered grease which is filtered a second time before entering the dispensing unit. In the case of the smallest miniature bearing (5/64-inch bore), the grease is injected with a hypodermic needle capable of controlling the amount of input to within 1 milligram. The bearing is weighed on a fine balance before and after lubrication to check the amount of grease introduced.

Most bearings require special shields or seals. As much as possible of the final testing is done before these are applied. All surfaces are first checked visually under 3× magnification. All final dimensional checking is done at this stage. During this sequence of operations, the bearings are subjected to a spin test for race quality and cleanliness, Fig. 11. A test for radial play must also be passed.

The requirement for supercleanliness is carried through to the final packaging of the product, which is also done in the clean room. Miniature bearings are packed in various ways, depending on their application. Some are packed individually in polyethylene bags; others are placed in airtight vials, several at a time, Fig. 12. Sometimes the bearing is packed swimming in oil, either in the bag or in the vial.

Miniature bearings produced under clean-room conditions are at the heart of the instruments and guidance systems on which America's space achievements are founded. Indeed, it is the consensus of leading scientists that the art of miniaturization, which makes it possible to pack the most intricate instruments into a minimum compass, has enabled this country to surpass Soviet accomplishments in this field in spite of the materially greater loads the Russians have placed in orbit.

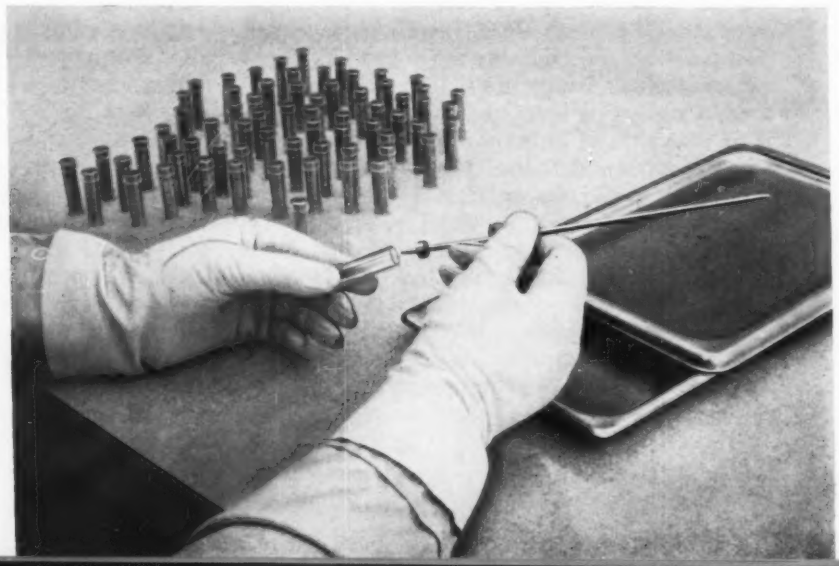


Fig. 12. Gloved hands of green-room operator package finished instrument bearings in vials as if they were surgical items.

MACHINERY'S Reference Section

How to Evaluate the Effects of Spline Misalignments on—

- *Interference Between Mating Splines*
- *Accurate Transmission of Motion*
- *Optimum Length of Engagement*
- *Beam Strength of Teeth*
- *Wear Loads on Teeth*
- *Load Capacity of Spline*

EARLE BUCKINGHAM

PART 1

AUGUST 1961

How to Evaluate the Effects of Spline Misalignments

EARLE BUCKINGHAM

In this two-part Reference Section the author presents simplified procedures for analyzing and calculating the various effects of misalignments on straight and crowned splines. Tables of comparative data have also been provided that show the effects of changing the number of teeth, material hardness, and misalignment angle

SPLINED SHAFTS are used both in tight-fit permanent assemblies and in sliding-fit connections between mating shafts and couplings. In the first application the spline teeth act as multiple keys and the contact between mating members is substantially full surface contact, so that if failure does occur it will generally be by torsional shear of the shaft below the roots of the teeth rather than as a result of any failure of the teeth themselves.

With splines of the clearance-fit, or sliding, type, on the other hand, failure may occur in other ways, including by shear of the teeth, compression of the teeth, breakage at the roots of the teeth due to bending, wear due to fretting corrosion, and bursting of the internal spline due to radial, tangential, and centrifugal stresses. The probability of failure in one or another of these ways is greatly increased by any misalignment of mating splines. It is therefore of some importance that the effects of misalignment be understood, quantitatively, and due allowance be made in the design. Factors such as tooth-form imperfections and spacing errors also have an effect on load and stress distribution, but these will not be considered here.

Contact Between Misaligned Splines

When the alignment of slidably connected shafts is perfect, contact conditions between teeth of the mating members are substantially surface contact, as in the case of tight-fit assemblies. Under these conditions the load capacity will be substantially the same as for permanent assemblies. Surface wear, if it does occur, will be largely limited to fretting corrosion that may develop from slight axial movement between the mating teeth due to operating conditions such as torsional deflection.

If misalignment is present, however, contact conditions are quite different from full surface contact, and the potential load-carrying capacity is reduced with increasing amounts of misalignment more rapidly than is generally appreciated. With misalignment, contact shifts from full surface to two teeth only. If the splines are not crowned, and if the materials are considered to be perfectly rigid, the contact would be edge or corner contact. One driving tooth would contact one end of the spline or coupling—whichever is the shorter—and the other driving tooth in contact would be diametrically opposite to the first, but at the other end of the spline or coupling. Adjacent teeth would have clearance, the amount of which increases as the angular distance from the driving tooth increases.

No material is perfectly rigid, however, so that elastic deformation of the materials will result in surface contact at the contacting edges, but with decreasing load intensities as the distance from the initial edge contact increases. When the amount of elastic deformation on the driving tooth is greater than the clearance between any adjacent teeth, contact will also exist on these teeth, but the amount of load they carry will be less than that on the initial driving tooth.

Determining Clearances and Interferences on Misaligned Splines

The first step in making an analysis of load distributions resulting from misalignments of driving teeth is to determine the amount of the clearances, or interferences, between the other teeth in the spline connection. The following symbols will be used in the analysis of these contact conditions:

Δ = angle of misalignment;
ϕ = angle of spline at middle (pressure angle of involute spline);
θ = vectorial angle of center line of spline, measured from hinge of misalignment;
N = number of teeth in spline;
F = face, or length of engagement of spline, inches;
R_1 = radius to middle of spline tooth, inches;
C = amount of clearance between teeth of spline, inches. (When the value of C is minus, then there is interference);
C_1 = corrected value of clearance when that on driving spline is zero.

When a straight spline is misaligned, one end is lifted above the center line and the other end is dropped, as shown in Fig. 1. The hinge of the misalignment falls at a point that is midway along the length of engagement. Presented in the following equation are the values of the interferences $(-C)$ and the clearances $(+C)$ for the various teeth when the spline is misaligned:

$$-C = \left(\frac{F \sin \Delta}{2 \cos \phi}\right) \cos (\theta - \phi) \qquad (1)$$

When the values of F, Δ, and ϕ are fixed, they become constants in Formula 1; the values of C and θ remain variables. The value of the derivative $dC/d\theta$ gives the rate of variation of the values of the clearances. When this value is equal to zero, then the clearances are at a maximum or minimum value.

$$(dC/d\theta) = \left(\frac{F \sin \Delta}{2 \cos \phi}\right) \sin (\theta - \phi) \qquad (2)$$

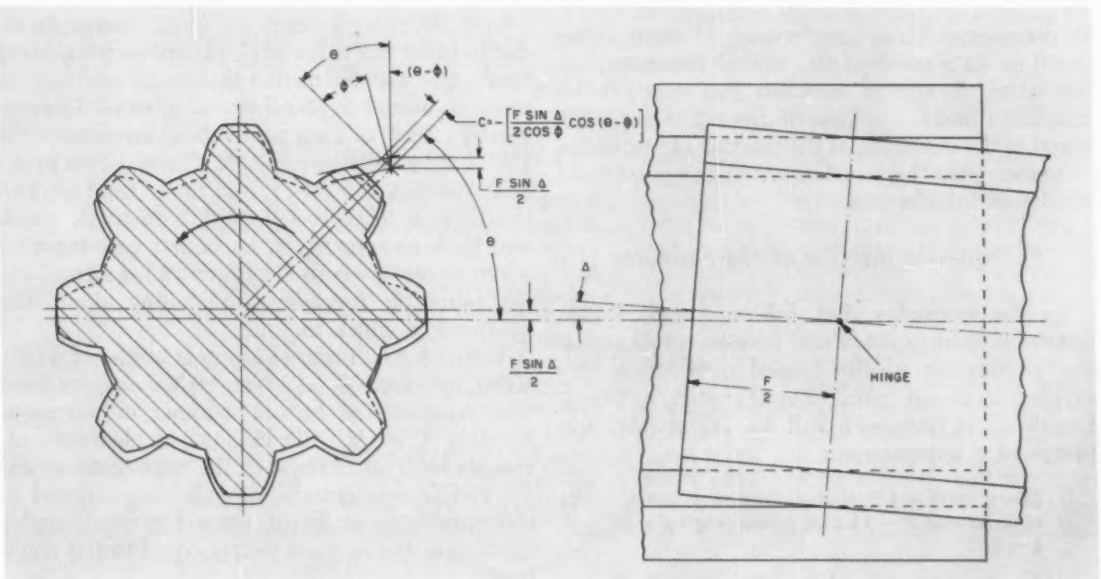
When $dC/d\theta$ in this equation is set equal to zero, then, since the value of $(F \sin \Delta/2 \cos \phi)$ of finite and fixed value, the value of sin $(\theta$-$\phi)$ must be equal to zero. Therefore,

$$\theta - \phi = 0° \text{ and } 180°$$
$$\theta = 0° + \phi \text{ and } 180° + \phi \qquad (3)$$

One of these values of θ represents the position of maximum interference, and will be for the driving tooth in the counterclockwise direction of rotation, as shown in Fig. 1. The other angular value will be the position of the tooth with the maximum amount of clearance, and this position will be at 180 degrees from the driving tooth.

Theoretically, there is a geometric factor which would shift these angular positions very slightly: the tipping of the internal spline through angle Δ changes the angular relationships of the teeth

Fig. 1. Clearance and interference conditions resulting from angular misalignment of splines.



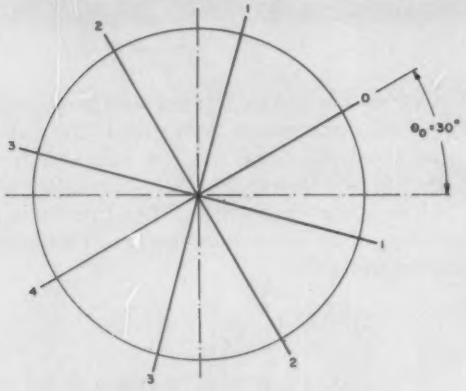


Fig. 2. Method of numbering tooth positions of an eight-tooth straight spline. The 0 indicates the position of maximum interference. The two teeth on either side of the 0 position both have the same amount of clearance or interference and both are designated 1. The same system is applied to the remaining teeth. Tooth position 4, opposite position 0, has maximum clearance.

on the internal member because it produces an elliptical projection in the plane of rotation of the coupling member. However, since the angles of misalignment being considered are only a very small fraction of a degree, this effect can be ignored.

Eliminating Interference Between Splines

In order for misaligned splines to mate without "cramping" of the teeth, it is necessary to reduce to zero any interference resulting from the misalignment. This may be done by increasing the width of the tooth spaces of the internal spline or decreasing the thickness of the teeth of the external member. In either case, whatever the amount of backlash required to reduce the interference to zero at the position of maximum interference, the same amount must also be added to the clearance, or interference, at every other position. As a result of this added clearance, the minimum amount of backlash that needs to be machined into the splines to prevent cramping is equal to the clearance at the position of maximum clearance *plus* the interference at the position of maximum interference.

Examples in the Use of the Formulas

In the examples that follow, standard 30-degree involute splines will be used to illustrate the application of the formulas. In these examples, a 2-inch pitch diameter and a 2-inch length of engagement will be maintained for purposes of comparison:

$N = 8$, pitch $= 4/8$, pitch diameter $= 2$ inches, length of engagement $F = 2$ inches, pressure angle $\phi = 30°$, and $\Delta = 0.05°$

$\theta = 0° + 30° = 30°$ and $\theta = 180° + 30° = 210°$

With eight teeth, the angular spacing of the teeth is equal to 360 degrees/N, which equals 45 degrees. When the driving tooth (the tooth with maximum interference) is identified, it will be numbered 0. The two adjacent teeth will both be numbered 1, and so on, as indicated in Fig. 2. The clearance conditions are symmetrical, so that all teeth with the same tooth numbers will have the same amount of clearance.

The calculations for the clearances of this eight-tooth spline are given in Table 1.

$$C = -(F \sin \Delta/2 \cos \phi) \cos (\theta - \phi)$$

$$\cos \phi = 0.8660254$$

$$\sin \Delta = 0.00087266$$

$$C = -0.00100766 \cos (\theta - 30°)$$

In this first example, the driving tooth is at 30 degrees, with an interference of $C = -0.00100766$ inch when $\Delta = 0.050$ degree. In order to bring the value of C_1 to zero on the driving tooth, the amount of this maximum interference must be added to all other values of C. The corrected values, or clearance values, are denoted as C_1. These clearance values of C_1 are shown in the sixth column of Table 1, and range from zero on the driving tooth to 0.00201532 on tooth No. 4, and back to zero again. Particular care must be given to use the correct plus or minus sign of the trigonometric functions, depending upon the quadrant in which they lie.

Values for C_1 for misalignment angles of 0.050, 0.100, 0.150, 0.200, 0.250, and 0.500 degrees have been computed in the same manner and are tabulated in Table 2. The amount of clearance increases with an increase in the misalignment angle and is substantially directly proportional to the misalignment angle, since for small angles the sine of the angle is nearly equal to the angle itself.

Table 1. Calculation of Clearances for 8-Tooth Splines of 4/8 Pitch, 30-Degree Pressure Angle, 2-Inch Length of Engagement, and 0.05-Degree Misalignment Angle.

Tooth No.	θ	$(\theta\text{-}30^\circ)$	$\cos(\theta\text{-}30^\circ)$	C	C_1
0	30	0	+1.000	−0.00100766	0
1	75	45	+0.70710678	−0.00071252	0.00029514
2	120	90	0	0	0.00100766
3	165	135	−0.70710678	+0.00071252	0.00172018
4	210	180	−1.000	+0.00100766	0.00201532
3	255	225	−0.70710678	+0.00071252	0.00172018
2	300	270	0	0	0.00100766
1	345	315	+0.70710678	−0.00071256	0.00029514

Table 2. Clearances on 8-, 16-, and 32-Tooth 30-Degree Splines of 2-Inch Length of Engagement.

Tooth Number	Misalignment Angle, Δ, in Degrees					
	0.05	0.10	0.15	0.20	0.25	0.50
	Clearance, C_1, in Inches					
8 Teeth, 4/8 Pitch						
0	0	0	0	0	0	0
1	0.00029514	0.00059028	0.00088541	0.00118055	0.00147569	0.00295137
2	0.00100766	0.00201532	0.00302299	0.00403064	0.00503830	0.01007659
3	0.00172018	0.00344036	0.00516057	0.00688072	0.00860093	0.01720180
4	0.00201532	0.00403064	0.00604598	0.00806132	0.01007662	0.02015323
16 Teeth, 8/16 Pitch						
0	0	0	0	0	0	0
1	0.00007670	0.00015340	0.00023010	0.00030680	0.00038350	0.00076700
2	0.00029514	0.00059028	0.00088541	0.00118055	0.00147569	0.00295137
3	0.00062205	0.00124410	0.00186615	0.00248820	0.00311025	0.00622049
4	0.00100766	0.00201532	0.00302298	0.00403064	0.00503830	0.01007659
5	0.00139327	0.00278654	0.00417981	0.00557308	0.00696635	0.01393269
6	0.00172018	0.00344036	0.00516054	0.00688072	0.00860090	0.01720180
7	0.00193862	0.00387724	0.00581586	0.00775448	0.00969310	0.01938619
8	0.00201532	0.00403064	0.00604598	0.00806132	0.01007662	0.02015323
32 Teeth, 16/32 Pitch						
0	0	0	0	0	0	0
1	0.00001936	0.00003872	0.00005808	0.00007744	0.00009680	0.0019360
2	0.00007670	0.00015340	0.00023010	0.00030680	0.00038350	0.00076700
3	0.00016982	0.00033964	0.00050946	0.00067928	0.00084910	0.00169820
4	0.00029514	0.00059028	0.00088541	0.00118055	0.00147569	0.00295137
5	0.00044783	0.00089566	0.00134349	0.00179132	0.00223915	0.00447830
6	0.00062205	0.00124410	0.00186615	0.00248820	0.00311025	0.00622049
7	0.00081108	0.00162216	0.00243324	0.00324432	0.00405540	0.00811080
8	0.00100766	0.00201532	0.00302298	0.00403064	0.00503830	0.01007659
9	0.00120424	0.00240848	0.00361272	0.00481696	0.00602120	0.01204240
10	0.00139327	0.00278654	0.00417981	0.00557308	0.00696635	0.01393269
11	0.00156749	0.00313498	0.00470247	0.00626996	0.00783745	0.01567490
12	0.00172018	0.00344036	0.00516054	0.00688072	0.00860090	0.01720180
13	0.00184550	0.00369100	0.00533650	0.00738200	0.00922750	0.01845500
14	0.00193862	0.00387724	0.00581586	0.00775448	0.00969310	0.01938619
15	0.00199596	0.00399192	0.00598788	0.00798384	0.00977980	0.01995960
16	0.00201532	0.00403064	0.00604598	0.00806132	0.01007662	0.02105323

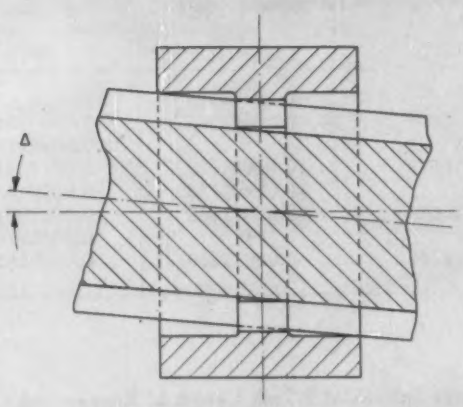


Fig. 3. Method of restricting length of spline engagement by counterboring external member.

The minimum backlash needed to permit the specified angle of misalignment without cramping is equal to the maximum clearance on tooth No. 4. This is equal to 0.00201532 inch for the 0.050-degree misalignment. The allowance on the outside diameter of the spline must equal

$$F \sin \Delta \qquad (4)$$

as may be seen from Fig. 1. This amounts to about 0.00175 inch for the 0.050-degree misalignment.

In operation, each pair of mating teeth will carry its maximum load as it passes through the angle of θ_0, which is the position of the driving tooth. When the elastic deformation of the teeth at the driving-tooth position is greater than the amount of the clearance at other positions, a lesser load will be carried in that position, since some of the total load transmitted will then be carried by teeth at these other positions. When the amount of clearance at other positions is greater than the elastic deformation at the driving position, no load will be carried at those other positions. Thus, as the shaft rotates, the load on each tooth of the spline will vary from a minimum or zero value, rise to a maximum, and then reduce again. During this rotation, there will also be a small amount of sliding in an axial direction because of the misalignment. The amount of this sliding will increase as the angle of misalignment increases.

In addition to the data for eight teeth computed in the first example, values for sixteen and thirty-two teeth have been determined and have been tabulated in Table 2 for convenient comparison. It should be noted that regardless of the number of teeth, the maximum clearance for any given misalignment angle, diameter of spline, and length of engagement remains the same; but with greater numbers of teeth, the increments of clearance between successive teeth are smaller.

Relation of Length of Engagement to Clearances

For any given angle of misalignment, the amount of the clearances will be directly proportional to the length of engagement of the splines. Thus, length of engagement should be kept to the minimum that is adequate to carry the load.

In the examples summarized in Table 2, a length of engagement equal to the pitch diameter of the involute splines has been used. If this length were reduced to one-quarter of this diameter, for example, the amount of the clearances for any given misalignment angle (for the same diameter and number of splines) would be reduced to one-quarter of the tabulated values.

Fig. 3 shows one method of restricting the length of engagement of a splined member which has axial freedom on a splined shaft. The diameters of the counterbores should be predetermined to restrict the misalignment angle to some maximum value.

For a perfectly aligned 2-inch pitch diameter, 30-degree involute spline with a length of engagement equal to 0.500 inch (one-quarter of the pitch diameter), the safe maximum transmitted load would be equal to or slightly greater than the safe torsional load on the splined shaft.

Estimated Load Capacity of Misaligned Splines

On a misaligned splined shaft and coupling, the initial contact is made on the corners or edges of the two driving teeth at opposite ends of the engagement, at 180 degrees from each other. Under load, these edges are deformed elastically in the general form of a wedge whose thickness varies from a maximum at the position of the initial contact to a minimum along the face of the contacting teeth.

When the amount of the initial deformation on the driving teeth is greater than the amount of the clearance on any of the adjacent splines, these other teeth will carry some part of the total load. The amount of the load carried will depend upon the amount of elastic deformation there. In other words, the elastic deformation of the materials will be used as a spring scale to weigh the load.

In order to obtain some measure of these loads, some safe maximum load intensity, in pounds per inch of full contact, must be selected. This could be the load that would keep the bending stress at the root of the spline tooth within the bending endurance limit of the materials.

The next essential is to have some measure of the amount of elastic deformation which would be set up by the applied unit load intensity. The safe maximum intensity of the applied load is imposed only at the edges of the two driving teeth; everywhere back of these edges the intensity, and deformation, will be less. The maximum thickness of the deformation wedge of the two driving teeth, therefore, is equal to the amount of elastic deformation set up by the maximum unit load intensity acting at the edges of the teeth. On adjacent teeth, the maximum thickness of the deformation wedge is equal to the difference between the maximum deformation on the driving teeth and the amount of clearance on the adjacent teeth. No load will be carried on any teeth where the amount of clearance is greater than the maximum deformation on the driving teeth.

The minimum thickness of the deformation wedge will depend upon the angle of the wedge and the length of contact. This minimum thickness will be zero when the length of the deformation wedge is less than F, the nominal length of contact of the splines. When the calculated length of contact is greater than the nominal length of contact, the minimum thickness of the wedge will be equal to the extra length of contact multiplied by the tangent of the angle of the wedge.

The actual angle of the deformation wedge will be somewhere between the misalignment angle and zero. For the sake of simplicity, it will be assumed as a constant value which will be equal to the misalignment angle Δ. This is shown in Fig. 4. (Note: The actual angle of the deformation wedge on each spline tooth varies between 0 degree and Δ, depending upon the angular position θ of the tooth, and may be calculated from the relation $\tan \beta = \tan \Delta \cos \theta$, in which β is the actual wedge angle at position θ.)

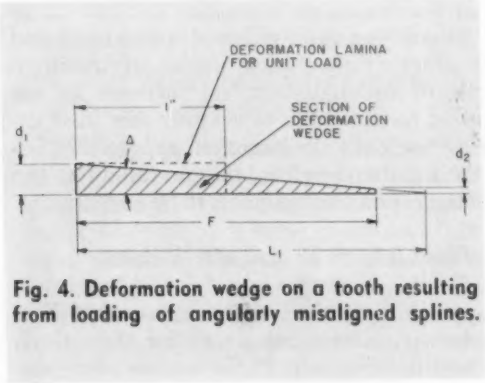


Fig. 4. Deformation wedge on a tooth resulting from loading of angularly misaligned splines.

Limiting Unit Load Values

To begin the analysis, a limiting stress S for reversed bending of 40,000 psi (for about 225 Bhn steel) will be used with the Lewis form factors Y for 1/2-pitch splines to obtain a unit load value W in pounds per inch of face per tooth. Harder and stronger materials will have other limiting stress values. Using the Lewis formula,

$$W/\text{inch} = SY/P, \qquad (5)$$

this gives the following values for 1/2-pitch, 30-degree involute splines:

N =	8	12	16	20	24	32	40
W/inch =	28,525	30,662	32,672	33,803	34,683	35,688	36,442

The Lewis form factors Y used in computing these values were obtained graphically and are given in the accompanying table.

Lewis Form Factors for 30-Degree Involute Splines

N =	8	12	16	20	24	32	40
Y =	0.713	0.767	0.817	0.845	0.867	0.892	0.911

For 2-inch diameter splines of other pitches we have the following values for W, which were obtained by dividing the foregoing values by the diametral pitch used:

N =	8	12	16	20	24	32	40
P =	4/8	6/12	8/16	10/20	12/24	16/32	20/40
W/inch =	7132	5110	4084	3380	2890	2230	1822

Elastic Deformation Under Load

For the standard 30-degree involute splines with an approximately uniform load from tip to root, the load per inch of face required to deform a tooth by an amount of 0.001 inch would be about 4000 pounds on a perfectly aligned spline. The value of the maximum deformation would therefore be equal to the applied load per inch divided by 4000. This gives the following values for the maximum deformation of the several 2-inch pitch diameter splines:

N =	8	12	16	20	24	32	40
d =	0.001784	0.001277	0.001021	0.000845	0.000722	0.000557	0.000455

(These values also represent the maximum thicknesses d_1 of the deformation wedges on the driving teeth of misaligned splines.)

Deformation Wedges and Equivalent Tooth Loads

The amount of the load carried on each tooth may be estimated by using the assumption that this value will be proportional to the amount of elastic deformation. The area of the cross section of the deformation wedge will be compared with the area of the rectangular deformation lamina that would result from the application of the unit load on the straight tooth if there were zero misalignment. Fig. 4 shows these conditions.
When

Δ = misalignment angle;
F = length of engagement of splines, inches;
L_1 = length of zero thickness of deformation wedge, inches;
d_1 = maximum thickness of deformation wedge, inches;
d_2 = minimum thickness of deformation wedge, inches;
L_a = length of deformation wedge, inches;
a_1 = area of section of deformation wedge, square inches;
a_2 = area of section of rectangular deformation lamina under unit load, square inches;
W = unit load per inch of engagement with zero misalignment, pounds;
W_N = load carried on deformation wedge, pounds;
W' = total load carried on all contacting splines, pounds;
d = thickness of rectangul..r deformation lamina under unit load, inches (also equal to d_1 of driving tooth No. 0)

then, for any tooth in contact:

$$L_1 = d_1 \cot \Delta \tag{6}$$

When L_1 is greater than F, the value of L_a is equal to F, and the value of d_2 equals $(L_1 - F)$ tan Δ. When L_1 is less than F, the value of L_a is equal to L_1, and the value of d_2 is equal to zero.

$$a_2 = d \times 1.000 = d_1 \times 1.000 \tag{7}$$

$$a_1 = \left(\frac{d_1 + d_2}{2}\right) L_a \tag{8}$$

$$W_N = (a_1/a_2)\, W \tag{9}$$

The driving teeth at either end of the engagement are numbered 0. The adjajcent teeth are numbered 1, 2, 3, etc. Whenever the clearances are less than the value of d_1, some load will be carried on those teeth. Whenever the value of the clearance is greater than the value of d_1, no load will be carried on such teeth.

The total load carried, W', will be the sum of twice the load carried on tooth No. 0, twice the load carried on tooth No. $N/2$, and four times the loads carried on all other tooth numbers.

Example of Load Calculations

The eight-tooth, 4/8-pitch, 30-degree involute spline, with a length of engagement of 2 inches, whose clearances for various misalignment angles are given in Table 2, will be used for this example. The misalignment angle will be taken as 0.05 degree, and the several equations are solved in Table 3.

The total load for this misaligned spline, calculated in Table 3, is 40,440 pounds. This is only slightly more than one-third of 114,112 pounds, the load which can be carried on the same spline when the alignment is perfect. In both of these cases, the maximum root stress is the same.

A study of the values of W_N in Table 3 gives a picture of the load conditions on a given pair of mating teeth as they rotate under load. At the position of tooth No. 4, there is no load on the pair of teeth. The load begins to build up just before the position of tooth No. 3, and increases more and more until it reaches the maximum value at the position of tooth No. 0, then reduces to zero again as it passes the position of tooth No. 3.

The values for the total loads for misalignment angles up to 0.500 degree for this eight-tooth spline—and also those for the splines of the other tooth numbers—have been computed in the same manner and entered in Table 4 for comparison.

The loads tabulated are based upon the limiting bending stresses at the roots of the teeth. The shaft under the teeth, however, also has a limiting torsional stress condition that should not be exceeded. For the steel used in this example, the limiting torsional load should not exceed about 25,000 inch-pounds torque. This is the same as a 25,000-pound load applied at the 1.000-inch pitch radius of the splines.

Table 4 provides an interesting comparison as to the influence of the number of spline teeth and of the effect of increasing angles of misalignment. With misalignment, an increase in the number of teeth results in a lower safe load capacity. If the loads are increased appreciably beyond the tabulated values, fatigue failure at the ends of the contacting splines is to be expected.

Fluctuations in Angular Velocity

It appears that the best practice to follow would be to use as small a number of teeth as other conditions permit. There is some minimum

Table 3. Calculation of Loads on 8-Tooth, 4/8 Pitch Splines of 225 BHN Steel and with 0.05-Degree Misalignment angle.

$R_1 = 1.0$ inch; $F = 2.0$ inches; $\tan \Delta = 0.00087$; $\cot \Delta = 1145.9153$;
$W = 7132$ pounds/inch; $a_2 = 0.001784$ for 7132 pounds per inch

Tooth number N =	0	1	2	3	4
C_1 =	0	0.000295	0.001008	0.001720	0.002015
$d_1 = 0.001784 - C_1$ =	0.001784	0.001489	0.000776	0.000064	No load
$L_1 = d_1 \cot \Delta$ =	2.044313	1.706268	0.889230	0.073339	–
L_a =	2.000000	1.706268	0.889230	0.073339	–
$d_2 = (L_1 - F) \tan \Delta$ =	0.000038	0	0	0	–
$a_1 = L_a(d_1 + d_2)/2$ =	0.000911	0.000745	0.000338	0.000032	–
$a_1/a_2 = a_1/0.001784$ =	1.021300	0.712444	0.193385	0.001122	–
$W_N = 7132\ (a_1/a_2)$ =	7284	5081	1379	8	0

W^1 = total load = $2W_0 + 4W_1 + 4W_2 + 4W_3 + 2W_4$
= 14,568 + 20,324 + 5,561 + 32 + 0 = 40,440 pounds

Total load when $\Delta = 0°$ is $8 \times 2 \times 7132 = 114{,}112$ pounds
Limiting torque load at pitch line = 25,000 pounds

Table 4. Loads on Misaligned Splines; 2-inch Engagement; 225 BHN Steel

Δ=	0°	0.05°	0.10°	0.15°	0.20°	0.25°	0.50°
8-T, 4/8 pitch	114,112	40,440	13,820	7,340	4,480	3,100	1,456
16-T, 8/16 pitch	130,688	19,250	6,700	3,560	2,360	1,720	544
32-T, 16/32 pitch	142,720	8,780	3,080	1,670	1,080	755	272

Limiting torque load at pitch line = 25,000 pounds

number to use, however, to retain adequate smoothness of rotation. For example, if the number of teeth could be reduced to two, then the operation would be practically the same as that of a single universal joint, with a varying rate of rotation for the driven shaft. The amount of this variation increases with an increase in the angle of misalignment. With eight teeth as a minimum, however, the amount of variation in rotation would be reduced to much less than one-quarter of that for the single universal joint. With maximum angles of misalignment of 2 or 3 degrees, however, the amount of rotational variation should not be noticeable on power drives.

Effect of Shorter Length on Spline Capacity

To complete this analysis of misalignment of straight splines, the load capacities of the same splines but with the lengths of engagement reduced to 0.500 inch were computed. The clearances shown in Table 2 for 2-inch lengths were therefore reduced to one-quarter of the tabulated values, as indicated by Formula (1), since F has been reduced by three-quarters. The unit load and deformation values remain unchanged.

The loads for the shorter lengths of spline are computed in the same manner as before. However, with the shorter lengths of spline, the deformations from the loads on opposite ends of the spline may overlap and increase the root stresses unless the unit load value is reduced. For example, on the eight-tooth spline, tooth Nos. 0 and 4 are loaded concurrently from the contact on opposite ends, when the clearance is small enough to permit contact on tooth No. 4. In like manner, tooth Nos. 1 and 3 are loaded simultaneously from both ends. Also, tooth No. 2 is in the same condition.

The load calculation is started as before, and carried through until the value of d_2 on tooth No. $N/2$ is determined. If the length of the deformation wedge L_1 is greater than the length of engagement of the splines, then the unit load deformation on the loaded edge of tooth No. 0 must be reduced by one-half of the value of d_2 on tooth No. $N/2$.

The calculations of the loads on the teeth of the eight-tooth spline with a length of engagement of 0.500 inch are shown at the top of Table 5. The full length of the deformation wedge of tooth No. 0 is 2.044313 inches, so that the defor-

Table 5. Loads on 8-, 16-, and 32-Tooth Splines of 225 BHN Steel and 0.50-inch Engagement.

R_1 = 1.0 inch; W = 7132 pounds/inch; F = 0.5 inch; A_1 = 0.001784 inch
Δ = 0.05°; tan Δ = 0.00087; cot Δ = 1145.9153
Limiting Torsion Load at R_1 = 35,000 pounds

Sample Calculations for 8-Tooth Splines

Tooth No. =	0	1	2	3	4
C_1 =	0	0.000074	0.000252	0.000430	0.000504
$d_1 = 0.001784 - C_1$ =	0.001784	0.001710	0.001532	0.001354	0.001280
$L_1 = d_1 \cot \Delta$ =	2.044313	1.959515	1.755542	1.551569	1.466772
$L_1 - F$ =	1.544313	1.459515	1.255542	1.051569	0.966772
$d_2 = (L_1 - F) \tan \Delta$ =	0.001344	0.001270	0.001092	0.000915	0.000841

Since tooth number 4 is the driving tooth at the other end of the spline engagement and has 0.001784-inch deformation there, the total deformation there is 0.001784 +0.000841 = 0.002625 inch which exceeds the limiting deformation permitted by the maximum allowable stress. The deformation must therefore be reduced by 0.000841/2 at both ends. Thus, corrected unit deformation = 0.001784 −0.000421 = 0.001363 and the equivalent unit load = 1.363 × 4000 = 5452 pounds. The recalculation of the above data is as follows:

$d_1 = 0.001363 - C_1$ =	0.001363	0.001289	0.001111	0.000933	0.000859
$L_1 = d_1 \cot \Delta$ =	1.561883	1.477085	1.273112	1.069139	0.984341
$L_1 - F$ =	1.061883	0.977085	0.773112	0.569139	0.484341
$d_2 = (L_1 - F) \tan \Delta$ =	0.000924	0.000850	0.000672	0.000495	0.000421
La =	0.500	0.500	0.500	0.500	0.500
$(d_1 + d_2)/2$ =	0.001144	0.001070	0.000892	0.000714	0.000640
$a_1 = La\,(d_1 + d_2)/2$ =	0.000572	0.000535	0.000446	0.000357	0.000320
$a_1/a_2 = a_1/0.001363$ =	0.419662	0.392516	0.327219	0.261922	0.234776
$W_N = 5452\,(a_1/a_2)$ =	2288	2138	1783	1427	1279

W^1 = *total load* = $2W_0 + 4W_1 + 4W_2 + 4W_3 + 2W_4$
= 4576 + 8552 + 7132 + 5708 + 2558 = 28526 pounds

Comparison of Calculated Loads for 8-, 16-, and 32-Tooth Splines

Δ =	0°	0.05°	0.10°	0.15°	0.20°	0.25°	0.50°
Spline	Limiting Total Loads, W^1						
8T, 4/8 P	28,526	28,526	27,024	15,498	10,127	7,092	2,564
16T, 8/16 P	32,672	32,670	13,574	7,306	5,048	3,424	1,184
32T, 16/32 P	35,680	17,975	55,274	3,219	2,073	1,541	520

mation wedges of the teeth numbered 0 and 4 overlap each other. The thickness of the small end of the wedge of tooth No. 4, d_2, is 0.000841 inch. This condition will overload the tooth. The maximum value of 0.001784 inch must be reduced by 0.000841/2, which equals 0.000421 inch. Thus, the unit load value on tooth No. 0 must be reduced to one that develops a unit deformation of (0.001784 — 0.000421), which is equal to 0.001363 inch. Since it requires a unit load of 4000 pounds to give an elastic deformation of 0.001 inch, the new maximum unit load here will be 1.363 × 4000, which is equal to 5452 pounds per inch. The load calculation is then carried through as before with the revised unit load and deformation values. This has been done in Table 5.

The loads for all of the 0.500-inch face splines have been computed for misalignment angles up to 0.500 degree. These too are listed in Table 5.

A comparison of Tables 4 and 5 should be of interest. Except for the case of zero misalignment, the safe loads are generally larger for the 0.500-inch length splines than those for the longer length of engagement, and get relatively better as the angle of misalignment increases. It would appear that the engagement of straight splines should be kept as short as other conditions permit. In any case, the safe load to use is either the limiting torque load of the shaft or the tooth load for the maximum misalignment that is permitted—whichever is the smaller.

The second and final installment of this Reference Section on "The Effects of Spline Misalignments" will appear in the September number of MACHINERY.

DELMAR W. KARGER

Head, Department of Management Engineering
Rensselaer Polytechnic Institute
Troy, N. Y.

THINKING WITH MANAGEMENT

Use Industrial Engineers in Design and Development

A VAST MAJORITY of the nation's industrial firms are missing a "plus factor" in their engineering and research functions. They all use industrial engineers "out in the plant." Even conservative firms are instructing their campus recruiters to hire a few industrial engineering graduates. Yet, only a relatively small number of companies are cautiously introducing them into their engineering and research departments.

In almost every instance where they have been introduced, industrial engineers have made substantial contributions in engineering and research departments. Such men have proved highly valuable assets, especially in the project design or engineering team.

The trained industrial engineer is oriented toward the objective of producing quality goods at minimum manufacturing cost. He also knows that the vital starting point of a product or service is the design. The laboratory product may be beautiful and it may do everything everyone intended, but if it is not designed for fast, economical production it will never be a commercial success. Unless a company is producing museum pieces or designing for fun, it can easily go bankrupt with commercially unproducible designs. Even the world's best industrial or production engineers, located in the production function, are limited by the designs and specifications set by engineering.

As a manager, if you have production experience, think back. Have you often mumbled, "Our designers made a beautiful product, but did they ever worry about the factory? Why didn't they make it *this* way?" The design engineer instinctively "plays it safe" by specifying unreasonably tight tolerances and special and expensive finishes, and by using "exotic" metals, materials that are difficult to machine, or other familiar cost boosters. Why? First, he wants to be as sure as possible that the product will work; and secondly, he has no real quantitative concept as to what his actions are going to cost in material, tooling, or production dollars.

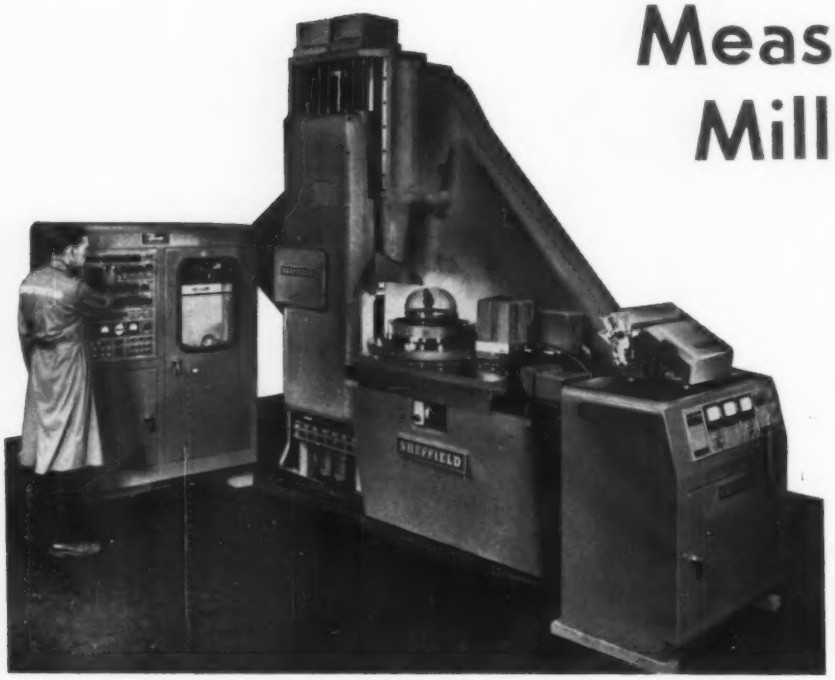
You may think you are giving him this information by feedback, from cost estimates; however, you are usually only "'kidding yourself." Not only do the industrial engineers think design engineers are overcautious, but the indictment is returned with usurious interest by design engineers. The latter are positive that the factory team is not completely intelligent, and that it is all the fault of manufacturing that the company cannot make a reasonable profit.

How can you expect feedback to work under such circumstances? Obviously, it cannot work, even when the situation is only half as bad as that illustrated. And, be assured, it is even worse on occasion.

There is only one way to sweep away this type of misunderstanding—tear down the mental barriers by actually having design and industrial engineers collaborate on product development. It is the only way that this rather natural hostility can be overcome. Management may not realize it, but the animosity tends to start on the college campus, and from there on it is continuously generated. In plants, the industrial engineer is practically always involved in the cost-estimating effort, and here he must deal with incomplete designs and spotty information. True, the design engineer cannot help the incomplete designs; but, by the same token, neither can the industrial engineer help complaining about the lack of information. From here on the divergence increases, since the costs are usually reestimated many times with only a few changes. Often products are started in actual production without complete information. Almost always, engineering ends up "squeezing out" some of the time originally allocated for production setup.

There is only one solution: put design and industrial engineers on the same team. In this manner they learn to understand each other's problems and to respect each other's knowledge and skills. When this happens, your chances of getting a producible design are infinitely greater.

Electronic Fingers Measure to Millionths



NUMERICALLY CONTROLLED precision measurement for automating a critical phase of this nation's missile and space program is demonstrated in a 16-ton system commanded by a roll of punched tape. In two hours it can complete almost 1000 precise measurements of a critical component, such as a missile nose cone, that would normally require about a month. Sensitivity is such that it can automatically detect a change as small as 10 millionths of an inch in the size of relatively large internal and external dimensions.

This universal, five-axis tape-controlled measuring machine is the first in a series of automatic measurement and print-out systems to be brought out by the Sheffield Corporation, Dayton, Ohio, designed for the simultaneous dimensional verification of internal and external contour and wall thickness to millionths-of-an-inch tolerance. In addition to its extreme accuracy and high rate of inspection speed, it eliminates the need for single-purpose gaging equipment and expensive fixtures for short production runs, and is readily adaptable to design changes.

Not only does this system measure and record the accuracy of parts with known dimensions, but it also can be used to determine and print out dimensions of a part of unknown size, within the range of the gage. The machine will accommodate work-pieces up to 20 inches high and 20 inches in diameter. Minimum inside work-piece radius is 2 inches.

Included in the system is an 8-ton, one-piece gage base with movable vertical and horizontal slides; an ultraprecise rotary table; a Bendix numerical-control unit; and a console containing the gaging and amplifying circuit, visual read-out meters, and automatic print-out system. Five axes of controlled motion are provided: (1) vertical—inside stylus; (2) vertical—outside stylus; (3) horizontal—outside stylus; (4) horizontal—work-table; (5) rotary movement of the work-piece.

Any point or angle within the gaging range will be measured to an accuracy of 1 ten-thousandth (0.0001) of an inch. Repeatability throughout the range is closer than plus or minus 5 millionths (0.000005) of an inch. Wall thick-

Rolling-ball tips of inside and outside sensing elements contact transparent part being checked on new universal, five-axis tape-controlled measuring machine. Millionths-of-an-inch size deviations are automatically measured and printed out simultaneously.

ness is measured to an accuracy of 50 millionths (0.000050) of an inch, and is the result of the machine automatically computing the algebraic difference between opposed gage points on the internal and external surfaces. All slides, both vertical and horizontal, operate within 15 millionths inch of true position. Two slide-mounted, rotating-ball Electrojet gage cartridges are the sensing elements.

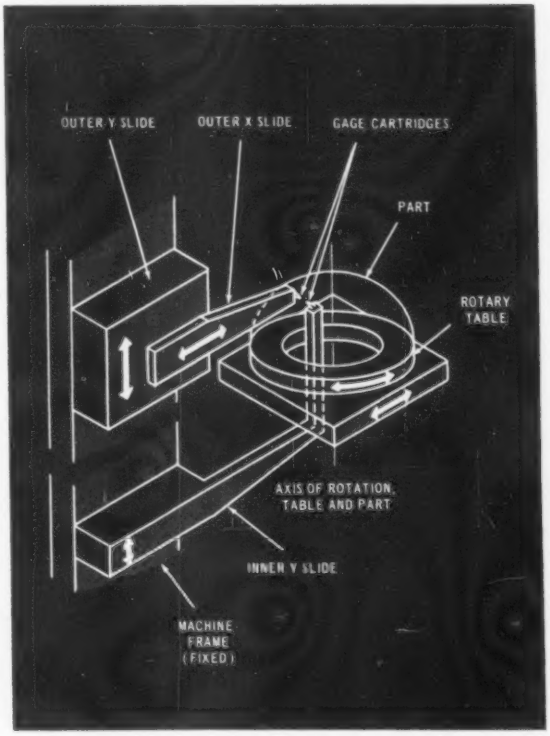
Each of the two vertical slides, as well as the horizontal slide, is independently controlled. Two servo systems are used on each. A power servo system moves the slides by means of hydraulic rams. An instrument servo system, which is independent of the power servos, detects the position of the slide and generates the signals necessary to control slide motion or to lock the slide in position.

To increase its versatility as a universal measuring instrument, the Sheffield machine provides three modes of gaging. They are:

Numerical-Control Scan Gaging—As the part is rotated slowly under tape control, any dimensional deviation exceeding preset limits causes the rotation to stop, at which time position and excessive deviation are printed out. The table then rotates a preset amount and stops. If deviation is still excessive, position and off-tolerance figures are again printed out. When the gage indicates deviation within the allowable limits, continuous scanning resumes. Such action, then, provides continuous scanning within set limits and automatic point-by-point inspection and recording of excessive deviation in one plane.

Numerical-Control Increment Gaging—Here, the rotary table, under tape control, advances a preset amount, stops, and deviation and position are printed out. Deviations within acceptable limits are printed in black, while those outside the limits are printed in red.

Operator-Control Gaging—Under this mode of gaging, the operator can manually set up all conditions that would normally be included in tape command. In addition, operator-control gaging permits a part of unknown dimensions to be explored, and slide positions printed out. Information obtained in this manner then becomes the manuscript tape for reproducing the part.



Basic motions of universal measuring machine are illustrated in this simplifed sketch. Five axes of controlled movement include two horizontal, work-table and outside stylus; two vertical, inside and outside styluses; and one rotary.

In Shops Around the Country

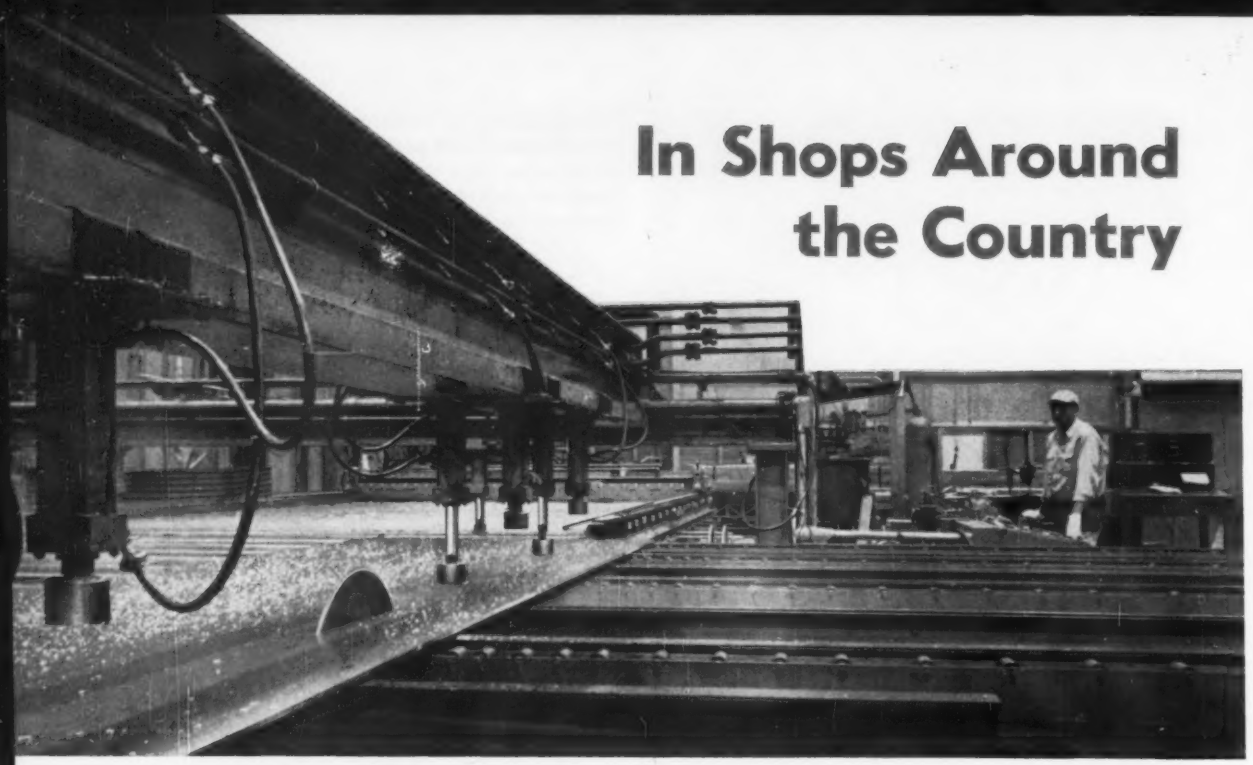
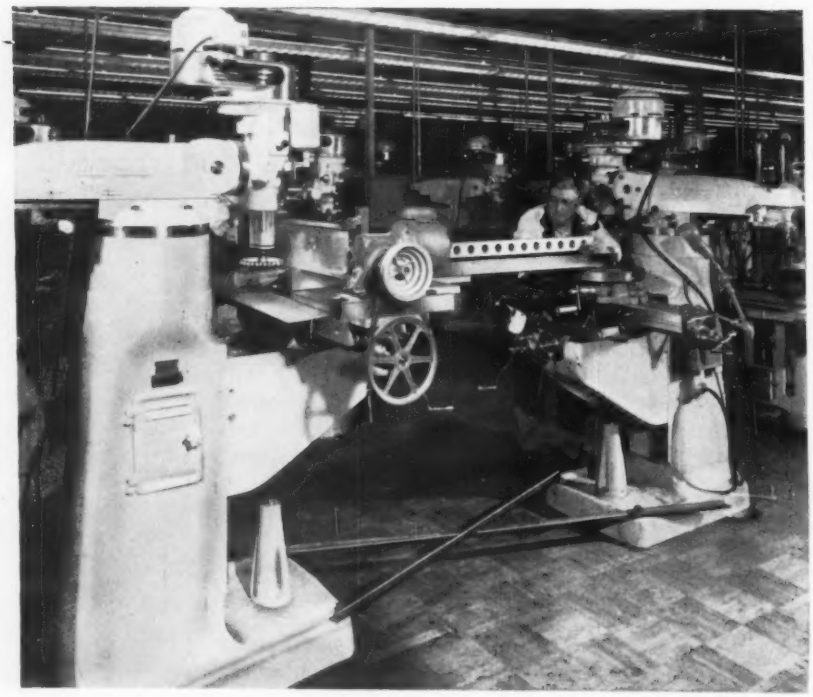


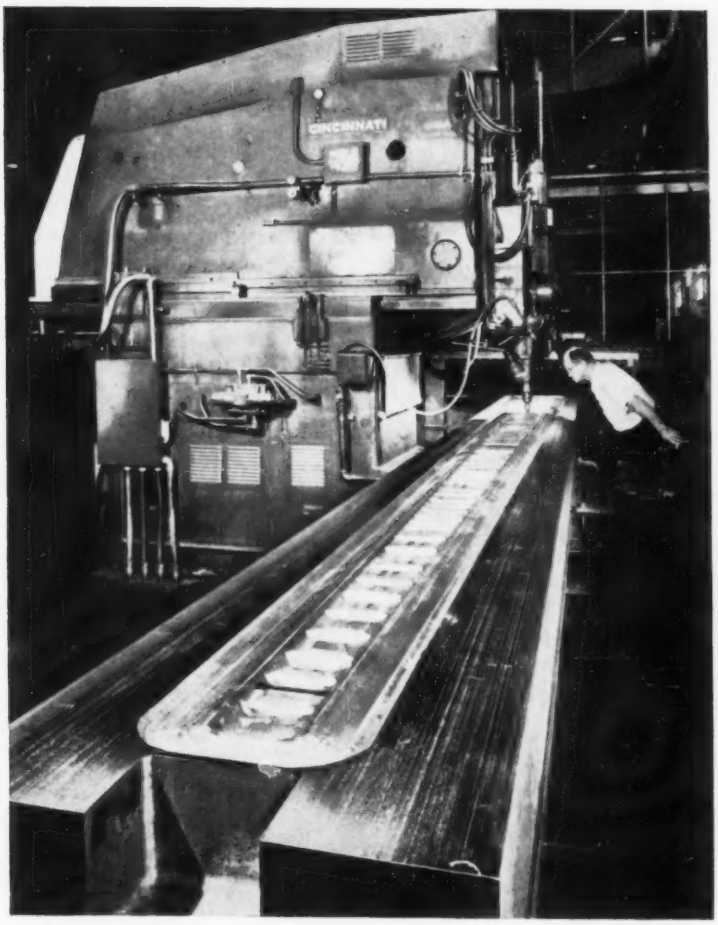
PLATE SAWING—Trimming and subdividing light alloy plates on an automated circular sawing machine at Kaiser Aluminum & Chemical Corporation's Ravenswood Works in West Virginia. Believed to be the world's largest such installation, this Loma machine comprises a 64-foot rip saw, a 14-foot cross-cut saw, and a 14-foot end-trim saw. Material up to 6 inches thick can be handled.



MILLING TEAMWORK—Machining a small section of a large-radius arc in a novel way at the Information Technology Laboratories, division of Itek Corporation, in Waltham, Mass. Two Bridgeport milling machines were joined at the base. The rotary table on one served as a pivot point, and the transverse feed on the other was loosened to give freedom of motion. Longitudinal drive of the second machine provided the feed movement.

Camera highlights of some interesting operations performed in various metalworking plants throughout the nation

METAL BONDING—Pilot plant for resolving shop problems in metal bonding at Boeing Airplane Co.'s Wichita, Kan., division is one of the most complete in the country. Equipment simulates that actually used in the company's metal-bonding shops. An engineer is preparing to cure an aluminum honeycomb sandwich on a steam-heated platen press. Steam circulates through the bottom platen, while the top platen applies the necessary pressure.



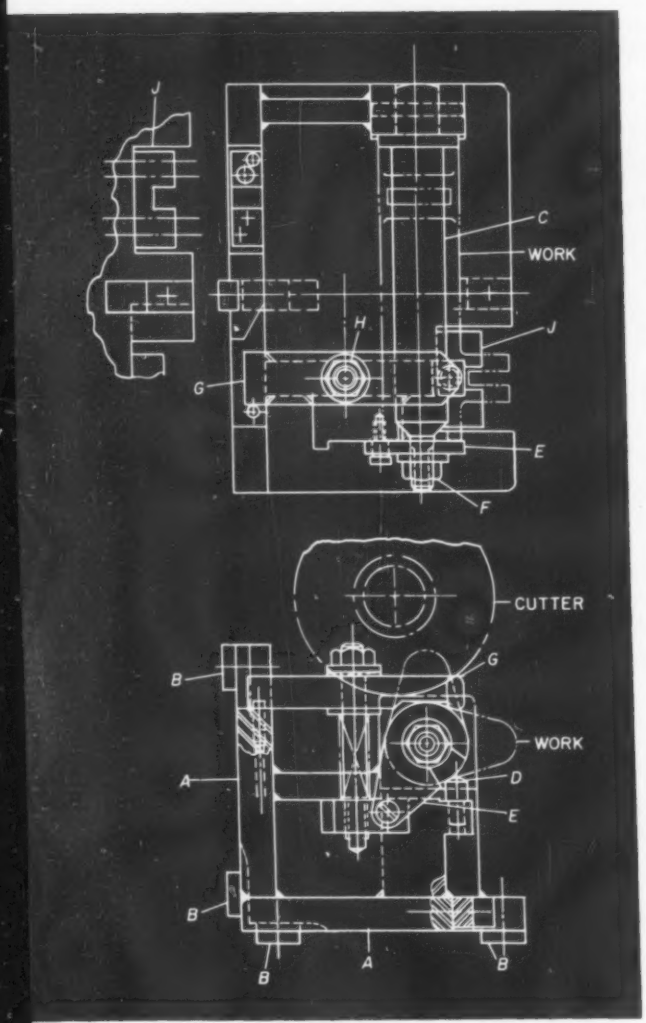
RECORD-SIZE DIE—Fillets are being machined on the ribs in the top half of a 14-ton die—14 inches thick, 26 inches wide, and 272 inches long. Subsequently, this die was installed in a 50,000-ton press to shape what is believed to be the longest closed-die forging ever produced. The part is a wing spar for North American's new twin-jet utility plane, the T-39 Sabreliner.

TOOL ENGINEERING *Ideas*

Tools and fixtures of unusual design and time- and labor-saving methods that have been found useful by men engaged in tool design and shop work

Modified Angle-Plate Serves as Milling Fixture

F. MURRAY, Chicago, Ill.

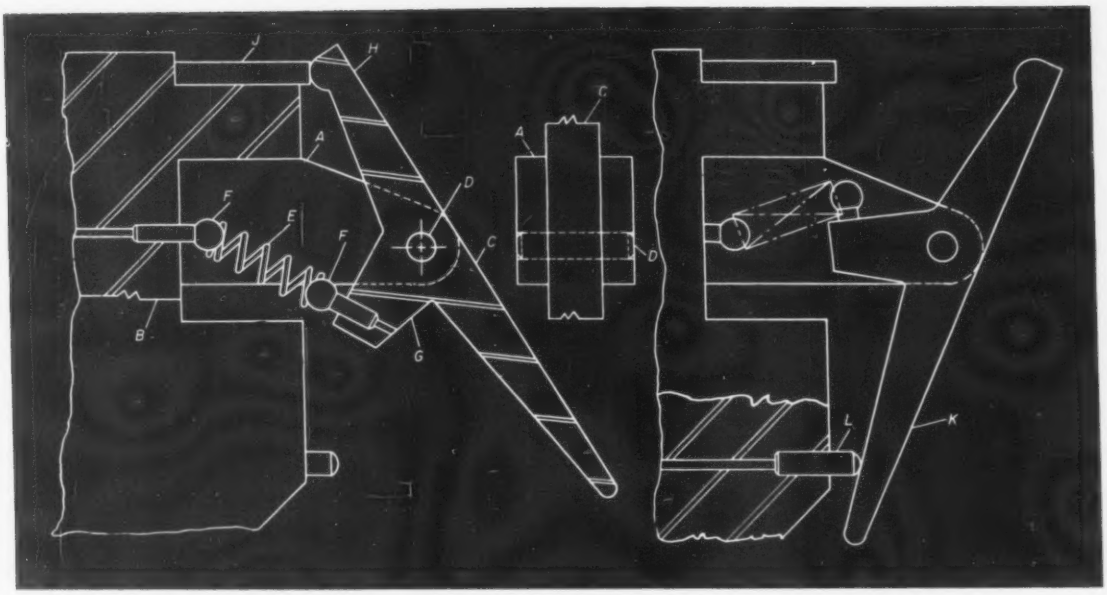


Designed in the form of an angle-plate, a fixture supported a bellcrank for the drilling of a slot in each of two lugs (in two separate operations). The lugs were at an angle of 90 degrees to each other. The job was run in small lots involving frequent setups. With one face of the angle-plate bolted to the machine table, one of the slots was milled in each piece in the lot. Then the other face was bolted to the table, and the other slot was milled. In preparatory operations, a hole was bored through the bellcrank body and both ends were faced.

A drawing of the fixture appears in the accompanying illustration. The work-piece is represented by the broken lines. The body of the fixture is a weldment, with each face *A* having keys *B* to engage a slot in the table. Shouldered mandrel *C* holds the work-piece. After a work-piece is slipped over the mandrel, it is located radially against rest button *D*. Then C-washer *E* is rotated over the end of the mandrel, and nut *F* is tightened. After spring-loaded clamp *G* is swung into position and nut *H* is tightened, milling proceeds.

The bottoms of the slots are clearances for links, so that they do not have to be exactly 90 degrees apart. For this reason, the same point on the rough casting of the bellcrank was used for radial positioning against the rest button for both slot-milling operations. Two cutter-setting gages *J* are attached to the fixture.

Each face of the angle-plate serves as a base for milling one of the two slots in the lugs of the bellcrank.



In clamping position, spring (E) rotates long leg (H) toward work-piece (J). When the clamp is pivoted, the spring rotates the long leg away from the work-piece.

Light-Duty Pivoting Clamp

CLIFF BOSSMANN, Dayton, Ohio

To locate a work-piece in a fixture for an assembly operation or a machining operation in which pressures are light, the illustrated quick-acting clamp can be used.

Clevis *A* extends from the body of fixture *B*. Clamp *C* pivots on dowel-pin *D* press-fitted in the clevis. Compression spring *E* is contained between two ball studs *F*, one being in the fixture and the other secured as illustrated in short leg *G*.

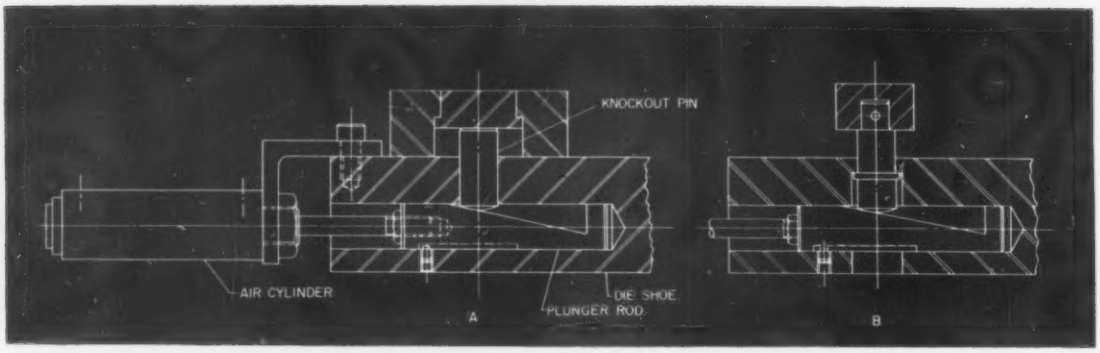
The view at the left shows the device in clamping position, with long leg *H* applying pressure on work-piece *J*. To unclamp the work-piece, as in the view at the right, handle *K* is pushed forward to stop-pin *L*. The base of the fixture beneath the stop-pin is cut off at an angle to provide finger clearance for pulling the handle forward.

Air Jet in Plug Gage Clears Holes

H. J. GERBER, Stillwater, Okla.

The production job shown involves the drilling and reaming of a large number of close-tolerance holes through a group of laminated plates. To adequately control tolerances, 100 per cent inspection was necessary as machining progressed. Checking of the holes was greatly facilitated by special "Go" and "Not Go" plug gages which were provided with air-jet holes in the end faces and also radially in the side walls. The gages, plus shutoff valves, were attached to hoses connected to the shop air line (illustration). Air pressure of about 50 psi was found sufficient to effectively clear the holes of all chips and cutting oil when the gage was inserted.

Chips and cutting oil are cleared from holes during checking by means of air jets provided in special plug gage. Gage, shutoff valve, and hose are connected to shop air line.



In View A, the knockout pin operates under the control of the air cylinder, which is timed with the upstroke of the press. Where the knockout pin is not contained above the die, it is provided with a shoulder and moves in a counterbored hole, as seen in View B.

Air Actuates Knockout

ROGER ISETTS, Kenosha, Wis.

When running high-production progressive dies, it is often necessary to knock the part out at the final station. This is particularly true if the part is bent. In many instances it is desirable, and sometimes imperative, to have the knockout arrangement deactivated while the die is closing and to operate and retract during the upstroke of the press. In such cases the knockout pad cannot be spring-loaded, so that it will not be in an up position during that part of the cycle when it is wanted out of the way.

Shown in View A is a simple yet positive method of obtaining such action. A hole is bored in the bottom die-shoe to a slip fit for a plunger. This plunger, made of drill rod and hardened, is machined at an angle to contact the knockout pin and is tapped in one end for attachment to the connecting-rod of a small air cylinder. A small slot is milled lengthwise for a dog-point set-screw which prevents the rod from turning during operation.

The air cylinder itself is a commercially available item, either double-acting or single-acting with a spring return. It is mounted on an angle-bracket which is bolted to the shoe. In use, the cylinder is actuated on the upstroke by a cam on the press crankshaft.

An alternate arrangement that can be employed in case the knockout pin is not contained is illustrated in View B. By this method a hole is counterbored from the bottom of the shoe and a shoulder turned on the pin to limit its travel. A mechanism similar to this can be attached to the top of the die-shoe if sufficient space is available, or if the design of the die lends itself to such a mounting.

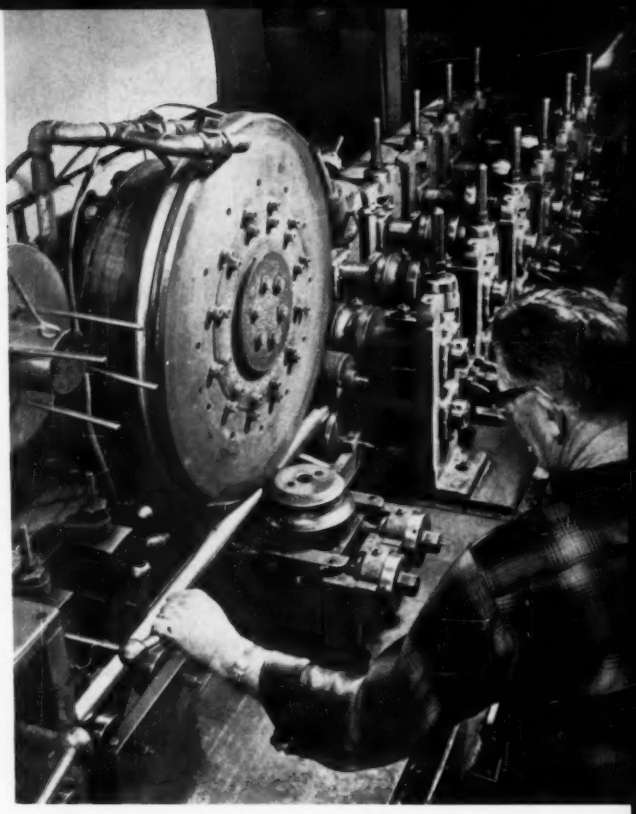
Film Offers Coolant Selection Formula

Production cost control in the highly competitive national and international metalworking markets is the theme of Master Chemical Corporation's new 16-mm color-sound motion picture, "Down With Unit Cost." A formula is offered for solving problems associated with proper coolant selection.

Touching the widespread problem of combatting foreign competition, the seventeen-minute film outlines the "Unit Cost Formula," cooperatively developed by Master Chemical and Dr. Milton C. Shaw, professor in charge, Metal Processing Department, Massachusetts Institute of Technology. The dramatic influence of proper coolant selection in long-range cost reduction is discussed. The significant contributions of Dr. W. W. Gilbert, director, Machining Development Service of General Electric Co., and Carboloy's new "Hi-E" program for determining high-efficiency machining operations are also presented and evaluated as aids to cost control.

Loan of film copies can be arranged by writing on company letterhead to Master Chemical Corporation, 13 N. Huron St., Toledo 1, Ohio.

Vapor-Cooled Welder Increases Tube Production



VAPOR-IMMERSION COOLING and a ribbon-wound core toroidal transformer with a two-section, low-impedance secondary have been combined to provide an efficient resistance type rotary welder of compact design. Developed by the Yoder Co., Cleveland, Ohio, for use in combination with tube mills (heading illustration) making welded tubing and pipe, the new welder is claimed to have resulted in production increases of 20 to 60 per cent, depending on tube size, without an increase in power input. Constructional features of the welder are shown in Fig. 1.

The primary and core of the transformer are cooled by a fluid dielectric which is sealed within the unit. As heat is developed, the liquid evaporates, comes into contact with the transformer case, is condensed, and returns to the liquid state. Heat is removed from the case by the water used externally to cool the electrodes. The liquid dielectric employed—FC-75—is colorless; odorless; and, for all practical purposes, inert.

The one-turn secondary consists of two sections—the secondary case and the electrode support. Aside from the electrode mountings, there is thus only one electrical joint in the secondary circuit. This is important, since in low-voltage systems joint resistance can cause high electrical losses. The result is a low-impedance secondary circuit delivering near-maximum amperage to the weld. Thin, improved insulation materials are used to reduce the spacing between the primary and secondary coils and further cut power losses. Although the unit is compact, the electrodes are large and generally require dressing only every two to three days.

One manufacturer, producing automobile and truck tail pipes from cold-rolled and aluminized steel with this equipment, is welding 2-inch diameter tube of 0.075-inch thick steel at 106 fpm. In another case, two operators make 3700 pieces of 101 1/4-inch sections or 6000 pieces of 69 1/2-inch aluminized steel sections during an eight-hour shift. One operator directs the continuous coil feed while the other tends the welder.

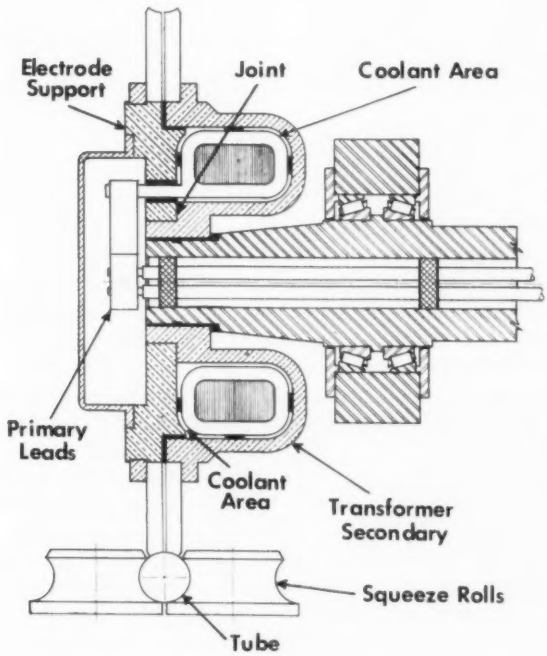


Fig. 1. Cross section of vapor-cooled rotary resistance type tube welder. To reduce power losses, the one-turn secondary consists of transformer case and electrode support. Inert liquid dielectric is sealed in coolant area.

New Computer Language Makes 3-Axis Contouring a Reality

Fig. 1. Autopromt-generated program controls Numeric-Keller miller generating three-dimensional cavities in gear-box cover for a helicopter.

COMPUTERS now can program Keller die-sinkers, generating all surfaces, including the fillets and other blend surfaces of intersecting solid geometric contours. By a simulated prototype command language, called Autopromt (AUTOmatic PROgramming of Machine Tools), computers such as IBM 704, 709, and 7090 produce three-axis machine tool control tapes through the technique of describing the surface to be generated, rather than the older APT method of plotting the path of the tool point.

The Autopromt system, announced by International Business Machines Corporation, was developed on the APT system under the sponsorship of the Aerospace Industries Association of America, Inc. (AIA), and will be available gratis to all who can use it. The concept is the result of a cooperative effort in which IBM, United Aircraft Corporation, and Pratt & Whitney Co., Inc., were the principal collaborators.

Demonstrated was the complete, from-the-solid contour-milling of a complex helicopter gear-box cover on a Pratt & Whitney Numeric-Keller—a tape-controlled, continuous-pattern, three-axis milling machine with Bendix control, Fig. 1. The system does not involve analog functions.

From a blueprint, only 180 one-line statements in the Autopromt language were written to describe the part completely. The solid-state IBM 7090 computer—using this information and controlled by the Autopromt master program—generated more than 8000 tool-path instructions. They spelled out to the Numeric-Keller every tool motion required to machine the part.

The computer's instructions, converted to standard perforated program tape for use by the Pratt & Whitney machine tool, enabled the milling job to be completed in about one-fourth the machining time previously required to mill the same part by conventional methods.

The saving in lead time is even greater. To produce this part by conventional methods required three months from blueprint to production. With Autopromt, any part of similar complexity can be put into production in two weeks, one-sixth the lead time normally required. Small machine shops with contouring machines will be able to employ the new computer language by using computers available at facilities such as IBM Datacenters.

Summarized, Autopromt capabilities are:

1. Simplicity in translating the blueprint into a finished part;
2. Accuracy and speed in machining complex three-dimensional parts;
3. Greater freedom in original design and engineering of parts;
4. Reduced lead time;
5. Expansion of numerical-control potential in machine shops of all sizes;
6. Sharp reductions in tooling costs for short-run production.

The new programming system's ability to program complex three-dimensional shapes is expected to offer engineers new freedom in realizing the original design intent of a product—both in mechanical function and in appearance. Designers no longer will have to compromise their efforts in order to avoid expensive hand tooling.

Similarly, parts for a development model may be produced more quickly, and in a form much closer to that planned for the production model, using the new system. As a result, Autopromt can speed up an entire development and production cycle, and reduce its cost simultaneously.

While mass-production methods require the

building of specialized machine tools, three-dimensional contouring makes possible automation of short-run production with available general-purpose, numerically controlled equipment. The function of the machine tool is specialized for the job at hand by the description fed into a computer in the prototypical language, Fig. 2.

Autopromt's concise, English-like language enables the part programmer, working from an engineering drawing, to describe the surfaces to be milled in familiar shop terminology. There are 110 words in the Autopromt vocabulary, with a great deal of built-in latitude for building up "sentences" and "paragraphs." This vocabulary has recently grown to 250 words.

Using this language, the part programmer describes each geometric surface of the shape to be machined, defines the relationships of these surfaces to each other, and specifies the machining requirements, such as tolerances and tool size. The vocabulary includes words that describe shapes and surfaces such as CONE, CYLINDER, HYPERBOLIC PARABOLOID, SPHERE, TAURUS, angle, axis point, intersection of, surface point, etc. For example, the programmer might use the following statement to define a bowl-shaped surface of a part to be machined:

BOWL = SPHERE, INSIDE/CENTER (0,0,0) RADIUS (1.75)

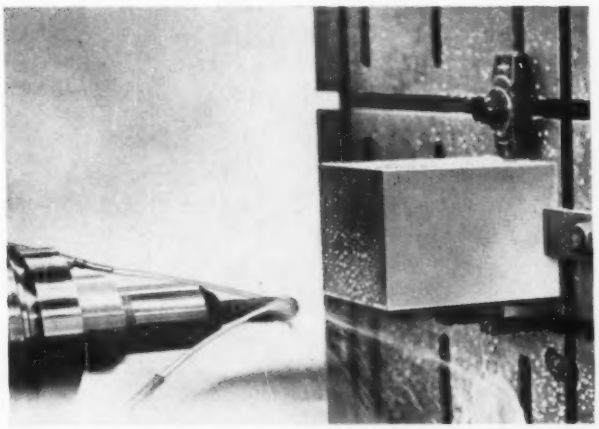
This statement tells the Autopromt program all it needs to know about the characteristics of the bowl-shaped surface. Other statements describe the relationship of this surface to other surfaces of the part.

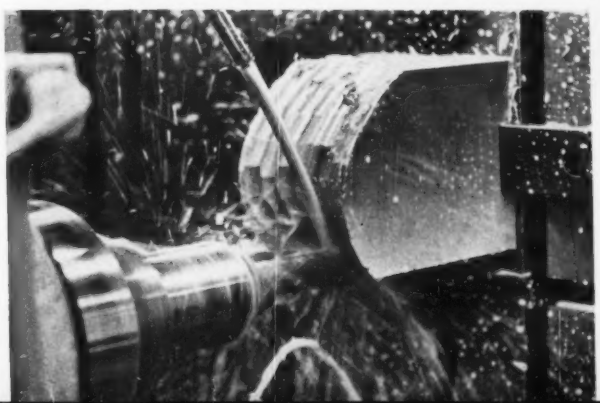
The part description, handwritten on an Autopromt coding sheet, then is punched into cards. The cards, in turn, are fed into the computer, which, under control of the Autopromt program, automatically generates the tool travel instructions for each surface to be machined.

The diagnostic abilities of Autopromt enable the computer to indicate by printed reports many types of errors which occur in the part description. For further verification, a printed list of coordinates for each tool position is prepared by the computer. These positions can be read or plotted to enable a manufacturer to visualize the path of the tool before the part is produced.

The Autopromt system is viewed as a step toward a highly sophisticated machine manufacturing method where the designer makes his calculations and programs them so that a computer will produce the part drawing to show its shape. It also produces a control tape for a machine which will produce the part automatically.

Fig. 2. (Upper left) Three-axis, numerically controlled tool point approaches blank for first bite. (Lower left) Saddle contour of part takes shape by Autopromt command. (Right) Roughly shaped saddle contour generated. Special increment programming can greatly refine surface produced from digital tape input, but it would take the computer a little longer to make the tape, and machining the part would, naturally, be slower.





NEW DEVELOPMENTS IN

Machine tools, unit mechanisms, machine parts, and

Brown & Sharpe Micromaster Surface-Grinding Machine

A 12- by 24-inch surface-grinding machine has been added to the Micromaster line built by the Brown & Sharpe Mfg. Co., Providence, R. I. This new machine (Fig. 1) is specifically designed for use in tool and die shops where its table, which is wide in proportion to its length, can perform highly accurate die grinding. The machine is also well-suited for general production work due to its fully automatic operation by the addition of an automatic slot and surface-grinding attachment, a wet-grinding attachment, and a vertical-position indicator attachment.

The massive antifriction, permanently lubricated spindle is powered by a 5-hp direct drive motor. The spindle is flange-mounted, allowing extremely accurate slot or shoulder grinding, a difficult problem in making intricate die sections. This feature is said to assure accuracy during the entire life of the machine.

The spindle upright moves on its own vee and flat way transversely, while the table is also mounted on a separate vee and flat way for longitudinal movement. This unique design feature assures long life of the original alignment accuracy. The upright ways and table ways are an integral part of the base, as shown in Fig. 2 (right, facing page). This design feature guarantees that the precise alignment between the table and wheel-slide will be retained throughout the entire life of the machine. Due to this exclusive design there can be absolutely no table twist at cross-feed. This provides for exceptionally accurate slot and side-wheel grinding operations.

A low-pressure unitized hydraulic system is easily accessible and requires very little maintenance. Automatic lubrication to all bearing surfaces is furnished by a separate system. Standard equipment furnished with the machine includes: rapid positioning, both transversely and vertically, at the rate of 50 ipm for minimum setup time; automatic truing speed of 10 ipm in either direction for accurate wheel dressing; and infinitely variable table speeds from 0 up to 125 fpm, giving smooth longitudinal motion at either low or high speeds, resulting in versatility in grinding any material. All controls are closely grouped for ease of operator handling.

Circle 565 on Readers' Service Card

Fig. 1. Surface-grinding machine, designed especially for use in tool and die shops, added by Brown & Sharpe to its Micromaster line

Edited by Freeman C. Duston

SHOP EQUIPMENT

material-handling appliances recently introduced

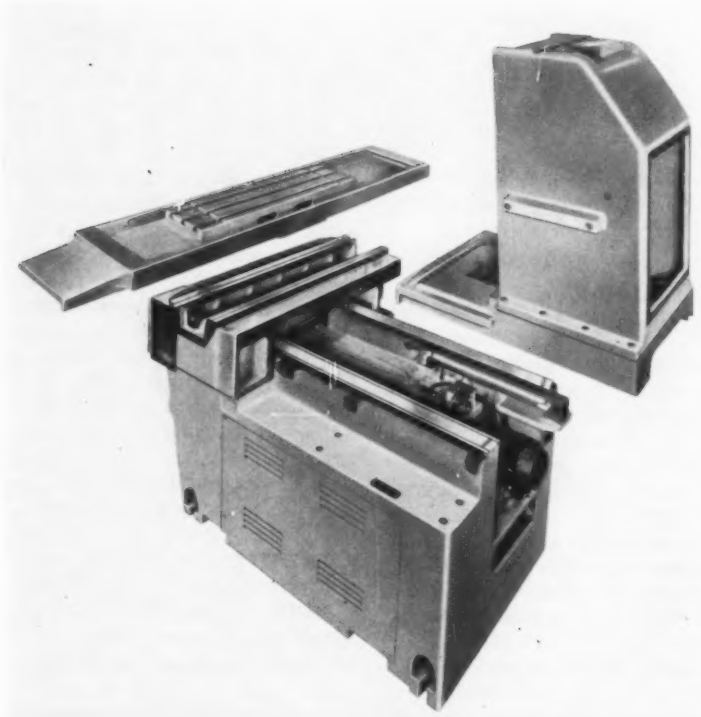


Fig. 2. Exploded view of B&S Micromaster surface-grinding machine's massive precision structural members

High-Speed "Multi-Slide" Machine

The U. S. Tool Company, Inc., Ampere, N. J., has added a Model MS-28-HS high-speed "Multi-Slide" machine to its line of metal-forming and stamping equipment. This new machine can be operated at speeds ranging up to 400 strokes per minute. It is equipped with specially constructed forming slides and a newly developed high-speed, positive grip type feed. Standard equipment includes one complete die-head with cam; back plate; tie-bar; four high-speed forming slides with cams; stripper mechanism with cam; high-speed, positive grip type feed; stock check; stock straightener; brake; automatic lubrication system; and 5-hp, variable-speed drive with output speeds from 80 to 400 strokes per minute. Die-heads are reversible and can be used from either front or back, giving the advantages of versatility both in operation and in the designing of tools.

Existing tooling for the standard No. 28 symmetrical Multi-Slide machine can be used in the new high-speed MS-28-HS without change. Special narrow die-heads are available in addition to the complete line of Multi-Slide auxiliary equipment.

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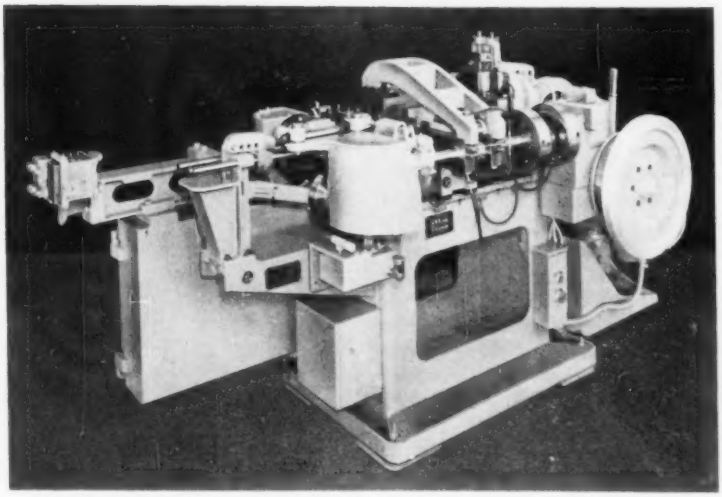

U. S. Tool Company high-speed Multi-Slide machine

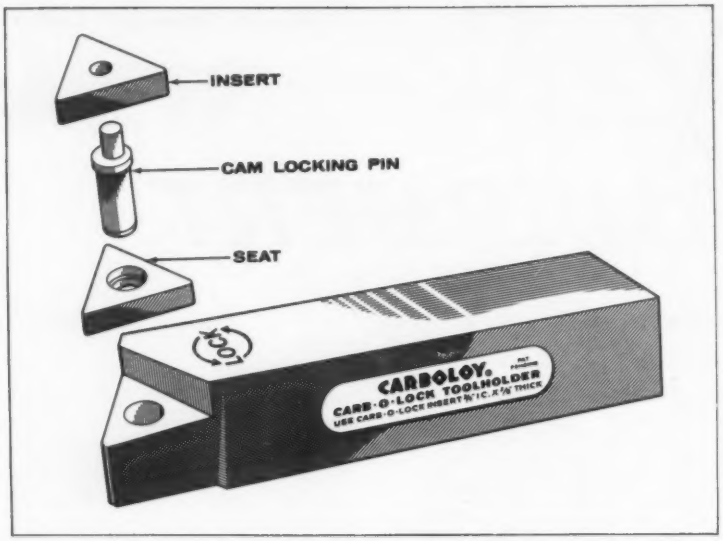

Fig. 1. Only three parts—a cam-action locking pin, seat, and shank—comprise the Carb-O-Lock tool-holder introduced by the Metallurgical Products Department of the General Electric Co.

Carboloy Carb-O-Lock Tool-Holder of Exceptional Design

All preconceived ideas were discarded and a completely new engineering approach was taken in developing the new Carb-O-Lock tool-holder brought out by the Metallurgical Products Department, General Electric Co., Detroit, Mich. The result is a revolutionary development in the design of disposable carbide tooling. Outstanding features of the new Carb-O-Lock tool-holder are its amazing simplicity and compact streamlining. The design is said to provide better functioning of the disposable carbide inserts and open the way for their use in many areas where they previously proved impracticable. Greater versatility, longer life, and lower costs are advantages also claimed for this new tool equipment.

The basic principle of the Carb-O-Lock tool-holder is a cam-action lock. The insert is engaged by an eccentric on the central cam locking pin. This provides a positive lock that cannot be loosened by vibration or cutting pressure. As the locking action takes place inside the insert rather than outside, there are no protruding screws or clamps—nothing to break or get washed off by chips. The "club head" and clamp have been eliminated, so that the holder and insert are as compact as a brazed tool. With only three parts (plus insert), as shown in Fig. 1, the holder is remarkably simple.

Tests indicate the exceptional holding power of the locking mechanism. The heaviest cuts on cast iron have failed to loosen the insert, which will break before it will become loosened, yet it is easily indexed. The self-cleaning, self-locating wrench socket is in the underside of the holder, where it does not become clogged with chips. Fig. 2 shows the operator using a socket wrench with his left hand to release the insert, while using his right hand to reposition the insert. Thus he can bring a sharp cutting edge into the working position without removing the tool-holder from the machine. The compact design permits greater work clearances and makes ganging practicable. The end-cutting edge angle is larger because no pocket is needed to retain the insert. This permits tracer applications where the plunge angle is not too acute. The holder may be used in many boring setups, and also for many applications in automatic machines.

The Carb-O-Lock tool-holder is offered in fifteen styles and 124 sizes for triangular and square inserts. Shank sizes range from 1/2 inch square to 2 inches square. The smaller sizes may be expected to replace brazed tooling in many applications. The inserts are now available in Carboloy Grade 883 for machining cast iron, and can be used on many machining applications on high-temperature alloys, Type 300 stainless steel, brass, and bronze. The inserts are specially processed with tolerances closer than utility ground—near the range of precision ground. As they will fit conventional holders, change-over is simplified.

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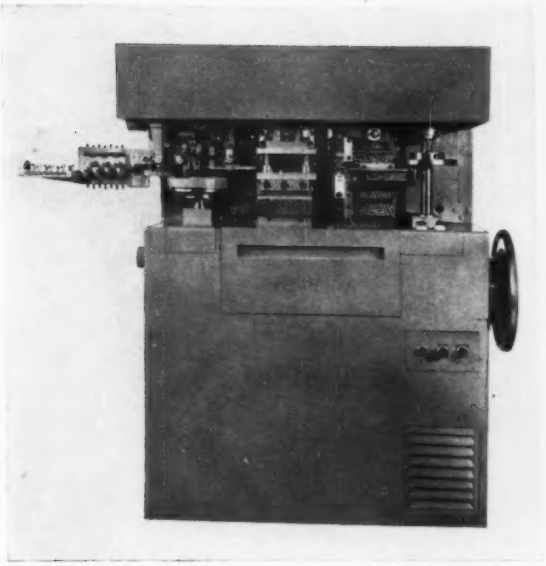
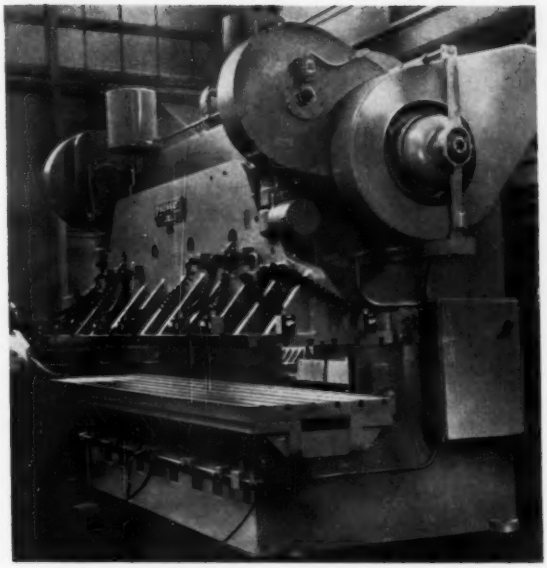
Fig. 2. Easy indexing of the insert of a Carb-O-Lock tool-holder is accomplished by simply loosening the locking pin with an Allen wrench



Torrington high-speed wire- and strip-forming machine



Cincinnati press brake adapted for press type operations

Vertical High-Speed Wire- and Strip-Forming Machine

A V-80 vertical metal-processing machine announced by the Torrington Mfg. Co., Torrington, Conn., is designed specifically for high-speed, precision production of small wire and strip components combined with unusually low setup time. A smaller version of Torrington's V-82 and V-81 vertical four-slide machines, the V-80 retains the versatility, visibility, and accessibility to press and forming tools that are inherent in the vertical design, and has a center-form treatment that is unique in four-slide machines. Because of the modular design of Verti-Slide subassemblies, welding, tapping, swaging, thread-rolling, and other secondary operations can be added to the primary forming cycle.

The V-80 stock capacity is 3/4-inch maximum strip width, 0.032-inch maximum strip thickness, and 1/16-inch maximum wire diameter. Production rates are from 100 to 500 strokes per minute with standard rise cams, and 100 to 350 strokes per minute with either maximum rise cams or feed lengths near the maximum (3 inches for strip and 5 inches for wire). An electrical brake, used in jogging for quicker setups, is standard equipment. Other major operating features includes: timing disc calibrated for 360-degrees, which eliminates trial and error in setting cams; interchangeable tooling, which permits shifting tools from one machine to another in the same size range without rework; either 90- or 180-degree feed; fourteen-roll strip- and wire-stock straightener with independently adjustable rolls; cam-actuated, self-contained press unit with a shut height of 4 inches; forming slides and slide bases attached directly to the machine bed and which can be removed as a unit without disturbing their fit; and handwheel for setting up, provided with an electric interlock to prevent power operation until the handwheel is in the inoperative position. The machine weighs 2000 pounds, is 66 inches long and 25 inches wide.

Circle 568 on Readers' Service Card

Press Brake Designed for Press Type Operations

The utilization of added die lengths and widths available in press brakes for press applications has been provided for in the design of the 9 series 10-foot Cincinnati (mechanical) press brake, manufactured by the Cincinnati Shaper Co., Cincinnati, Ohio. This machine develops a capacity of 225 tons at or near the bottom of the stroke. The 36-inch permanently widened bed and ram provide adequate backup for large die sets. In addition, the double-plate bed is equipped with a shelf for the adaptation of die cushions for press applications requiring such units.

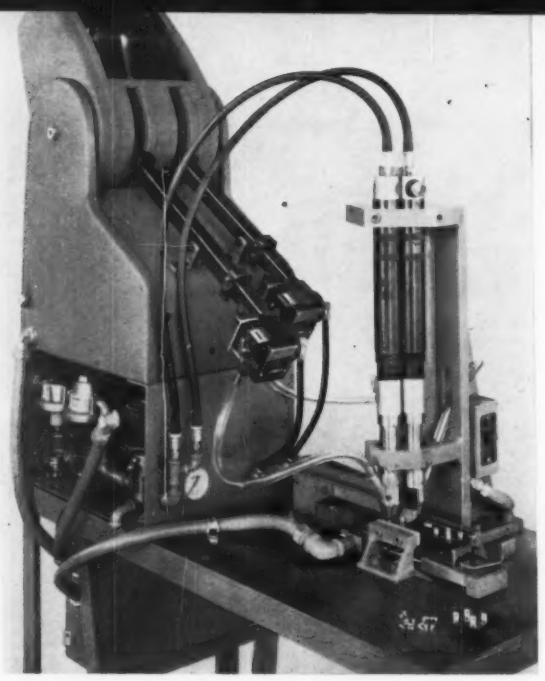
To facilitate the use of the overall die length—in this instance 14 feet—the press brake is furnished with 12-inch extensions on both ends. The machine is provided with an 18-inch throat, lowered to clear the top rear corner of the 3 3/4-inch thick by 36-inch wide T-slotted bolster plate.

Operator safety is provided for by palm buttons adaptable to either the bed or the ram, as illustrated. Sixteen palm buttons set up in series provide for a total of eight possible operators. These buttons are tied in to an air-electric clutch control so that all buttons must be depressed for machine operation.

Other features include: remote control to the power ram elevation, 5-inch stroke, air counterbalances, tonnage load indicator, electromagnetic brake on the ram-adjusting motor, automatic ram stop at the top of the stroke with nonrepeat feature, and reversing control.

Circle 569 on Readers' Service Card

Improved Ceco-Drop semiautomatic forging hammer announced by Chambersburg Engineering Co.



Tru-Tork automatic screwdriving machine developed by Clyde Engineering & Mfg. Co.

Chambersburg Ceco-Drop Semiautomatic Forging Hammer

The Chambersburg Engineering Co., Chambersburg, Pa., has incorporated many improvements in the current models of their Ceco-Drop hammers. The earlier models of this different type of gravity drop-hammer have set high standards of performance. Designed for work customarily assigned to the traditional board-drop hammer, the Ceco-Drop, by eliminating boards, rollers, pulleys, belts and motors, and gears, and raising the ram by air or steam, has eliminated the necessity for board replacement. Although the Ceco-Drop is easier and safer to operate, and costs less to maintain, the company continues to make a limited number of earlier designs of board-drop hammers.

However, the Ceco-Drop hammers have so clearly demonstrated their advantages that more than 140 forge shops now employ over 450 Ceco-Drop machines operating in regular production. Many former 100 per cent board-hammer shops have converted entirely to Ceco-Drops, and others have inaugurated a regular program of conversion.

The new Ceco-Drops now available have these additional features that further increase their effectiveness: (1) A new die-setting control makes die changes easier, quicker, and safer, and the ram can be "inched" up or down without fear of striking a power blow. (2) A faster-acting nonslip rod clamp gives instant reaction to the release of the operator's foot from the treadle. This positive clamping action results in uniform forging blows and more continuous operation. (3) The knock-off dogs are now equipped with nylon tips, reducing shock to valve control rigging and wear on the ram incline. Nylon tips are replaceable. (4) The Ceco Blowmatic program controller is available for converting any Ceco-Drop into a semiautomatic forging installation. Used in conjunction with the short-stroke control, long available with the Ceco-Drop, the Ceco Blowmatic comprises a selector switch (manual-automatic) mounted on the hammer frame, electrical control valves mounted on the hammer yoke, and a separate main control panel for the master controls.

The blow-pattern sequence for a particular forging, comprising so many long strokes and so many short strokes, is established on the main panel. When the sequence has been established, the operator places the stock in the die and steps on the treadle. The blows follow automatically, in exactly the pattern set. After the last blow, the hammer stops, with the ram clamped at the top of its stroke. When the operator steps on the treadle again, the same cycle is repeated. By turning the selector switch back again to manual, the hammer can be operated with individual blows, as the operator desires.

Circle 570 on Readers' Service Card

Screwdriving Machine

A dual-spindle Tru-Tork automatic screwdriving machine has recently been developed by Clyde Engineering & Mfg. Co., Madison Heights, Mich. Incorporated in the machine are two air-fed screwdrivers with Tru-Tork nosepieces and a special double-track oscillating hopper with two metering devices. In operation, a shuttle type fixture is used to push the part into position, where it is held firmly by a nylon pressure-pad. When the part is centered under the driving head, a limit switch is contacted which initiates the drivers.

Screws are simultaneously metered and driven while the operator positions the next part on the fixture. The automatic-cycle feature eliminates the necessity for

the operator to hit any electric switches and eliminates the handling of the screws and tool, thus leaving both hands free to load the fixture. Completed parts are automatically unloaded into a chute. The machine uses normal shop air pressure to operate driving heads and 40-psi air pressure to operate the metering device which feeds the screws. In the application illustrated, self-tapping No. 4 round-head screws are being driven in a 1 1/2-inch square oil-tight control unit manufactured by the Allen-Bradley Corporation.

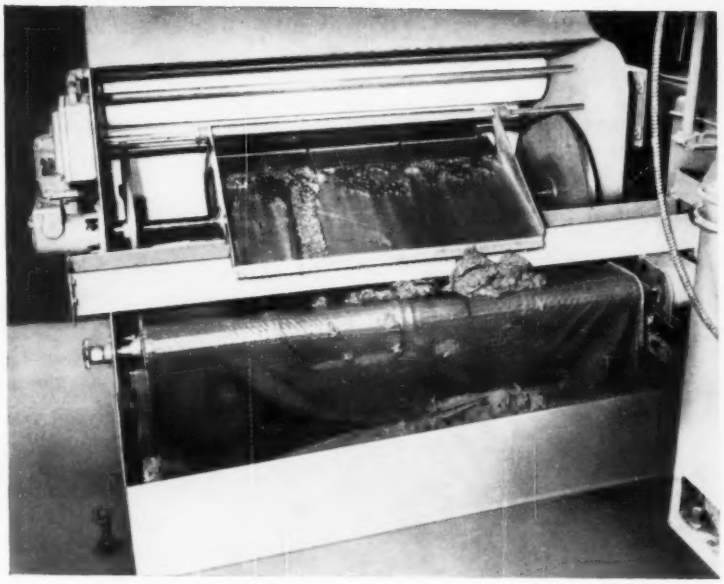
Circle 571 on Readers' Service Card

BarnesdriL "Two-Stage" Coolant-Cleaning Unit

The Barnes Drill Co., Rockford, Ill., is currently marketing a filtration unit that effectively removes all types of contaminant from coolants which vary through a wide range of viscosities. The BarnesdriL Kleenall filtration units, in five models with capacities from 1/2 to 60 gpm, perform "two stage" coolant cleaning. For these units, the popular magnetic separator has been combined with a fabric filter. In the first stage, dirty coolant flows through a powerful magnetic field that removes ferrous particles. In the second stage, the coolant passes through a filter medium which removes the nonferrous contaminants. The filter material is specially selected for its porosity which, in turn, depends upon job conditions.

The illustration shows the BarnesdriL Model MP 25 Kleenall filtration unit, installed on a Thompson True-Forming grinder, removing contaminants from coolant having a viscosity of 300 SSU and a flow rate of more than 5 gpm. The ferrous particles cling to the magnetic drum, and a scraper blade cleans the drum and deposits chips on the swarf chute. As coolant passes through the fabric filter, a seal wheel positively keeps dirty coolant from overflowing at the sides of the fabric. Flow of coolant through the float wash coupling removes any swarf that may accumulate on the float.

Circle 572 on Readers' Service Card

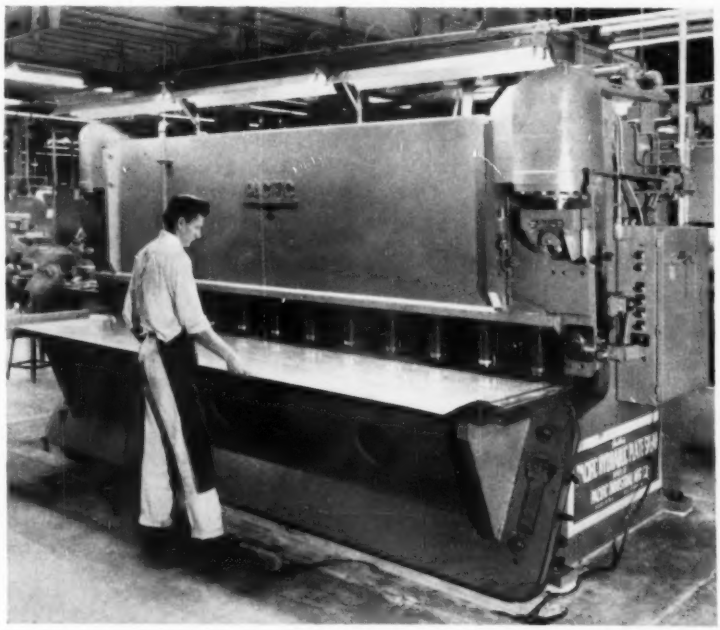


BarnesdriL cleaning unit installed on Thompson grinder

Hydraulic Plate Shear for Precision Cutting of Tissue-Thin Metal

A single heavy-duty hydraulic shear built by the Pacific Industrial Mfg. Co., Oakland, Calif., is being used to shear a complete range of materials from 0.005-inch thick sheet to 3/8-inch thick plate at the Naval Air Station, Alameda, Calif. With its rapidly adjustable knife clearance, this shear can be quickly set to 0.001 inch in less than fifteen minutes or reset for cutting steel, copper, stainless, or other alloys up to 3/8 inch thick. The reversible blades cushioned by hydraulic pressure have been used continuously for over a year without regrinding.

Circle 573 on Readers' Service Card



Pacific precision hydraulic sheet and plate shear

Thread rolling a sucker rod. The coolant: Gulfcut Heavy Duty Soluble Oil. It helps Liberty produce an unusually fine thread.

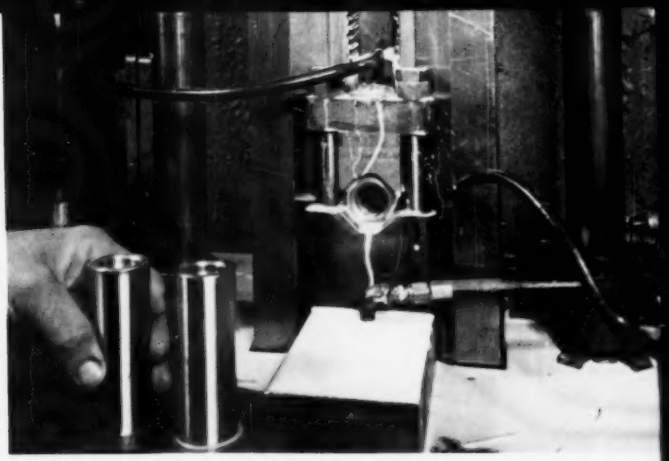
Change to Gulfcut® Heavy Duty Soluble saves thousands of dollars yearly...

Liberty Manufacturing Company has a certain distinction in the oil industry. This Fort Worth, Texas, firm was the first to market ½-inch sucker rods—used in oil wells to actuate the pumps which bring oil to the surface.

Some months ago, the company switched from a chemical coolant to Gulfcut® Heavy Duty Soluble Oil—and eliminated a costly degreasing operation. Previously, degreasing was necessary before sucker rods could receive a coat of protective paint.

"We use a ratio of 20 parts water to one part oil," says Mr. W. V. Barbee, Plant Superintendent. "The result: a light film of oil. It protects the rods against rust, yet isn't heavy enough to make us degrease before painting.

"We've benefited in other ways from the change-over. For instance, we haven't found one bit of rust in any machine-operated part. Paint peeling is no longer



Slotting a 5/8" couplet which fits on the end of a sucker rod. Gulfcut Heavy Duty Soluble Oil is the coolant.

W. V. Barbee, left, Plant Superintendent, and Frank Mauro, Gulf Sales Engineer. In background is stack of sucker rods.

Oil eliminates degreasing operation, GULF MAKES THINGS RUN BETTER!

a problem. And tool life seems to be much improved.

"Lastly, poorly rolled threads on sucker rod pins can lead to real trouble—broken joints out in the oilfields. But Gulfcut Heavy Duty Soluble Oil helps us get an almost perfect thread."

If you've got a tough machining problem, give us the opportunity to show you how Gulf makes things run better! Call a Gulf Sales Engineer at your nearest Gulf office. Or write for Gulfcut literature.

GULF OIL CORPORATION
Dept. DM, Gulf Building
Houston 2, Texas

GULF

Fig. 1. Presetting tools from drawing in Scully-Jones Quick-Set system

"Quick-Set" Tooling for Automatics

New cross-slide and turret tool-holders are now being manufactured by Scully-Jones & Co., Chicago, Ill., as part of a complete system for making chucking setups faster and easier. This "Quick-Set" tooling equipment is said to reduce job change-over time between 50 and 75 per cent, thus making it profitable to use single-spindle chucking machines on runs as small as twenty-five pieces. A job which normally might take four hours to set up on a chucking machine now can be tooled and ready to run in half the time. Repeat setups might average thirty minutes or less—from installation of chuck jaws through machining of the first piece. All cutting tools are preset in the Scully-Jones holders using bench gages (Fig. 1).

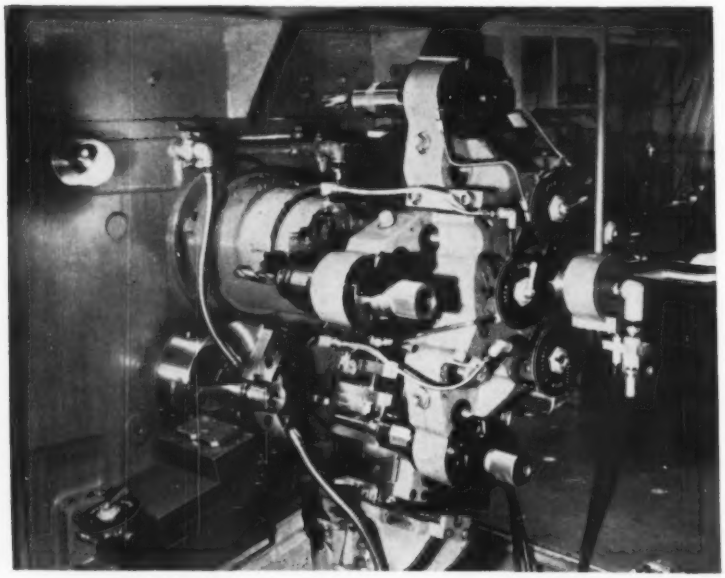


Fig. 2. Quick-Set tooling system has valve built in each tool-holding device to release or apply clamping pressure

Dimensions for setting are programmed on layout drawings. All tools are preset in fixtures to base lines which have been established on the machine. Thus, while the machine is producing pieces of one kind, cuttings tools for another job can be made ready to machine accurate parts on the very first cut after change-over.

No wrenches are needed to install the Scully-Jones tool-holders. Holders for end-cutting tools are inserted into hydraulically actuated chucks such as shown on the chucking machine, Fig. 2. A valve is built into each cross-slide magazine clamp and turret tool-holder chuck to apply and/or release hydraulic pressure. Cross-slide tools shown at left, Fig. 3, are held

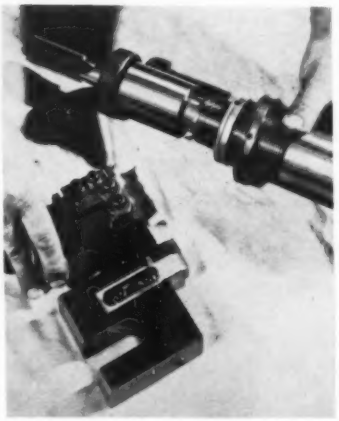


Fig. 3. (Left) Magazine for cross-slide tools of Scully-Jones Quick-Set system. (Right) Turret tool-holders for end-cutting tools

in magazines and clamped in place by heavy disc springs. Spring pressure is released by a hydraulic piston. Turret tool-holders like the one shown at the right in Fig. 3, for end-cutting tools, are held in hydraulic chucks. To remove tools, the operator simply opens a valve.

The manufacturer guarantees this system to hold machining tolerances to plus or minus 0.001 inch. In actual practice, however, much closer tolerances are possible. A side benefit of Quick-Set tooling is that the operator can check his cutting tools visually in seconds and replace them without in-the-machine adjustments.

Circle 574 on Readers' Service Card

SPRING DESIGN DATA—3

Compression Springs—Graphical Description of Load-Deflection Characteristics

In order to properly specify or design a compression spring, it is first necessary to understand how a spring reacts when load (P) is applied causing it to deflect, or compress — the load-deflection characteristics of the spring.

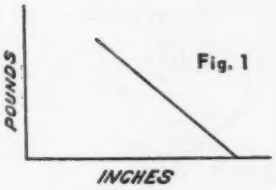


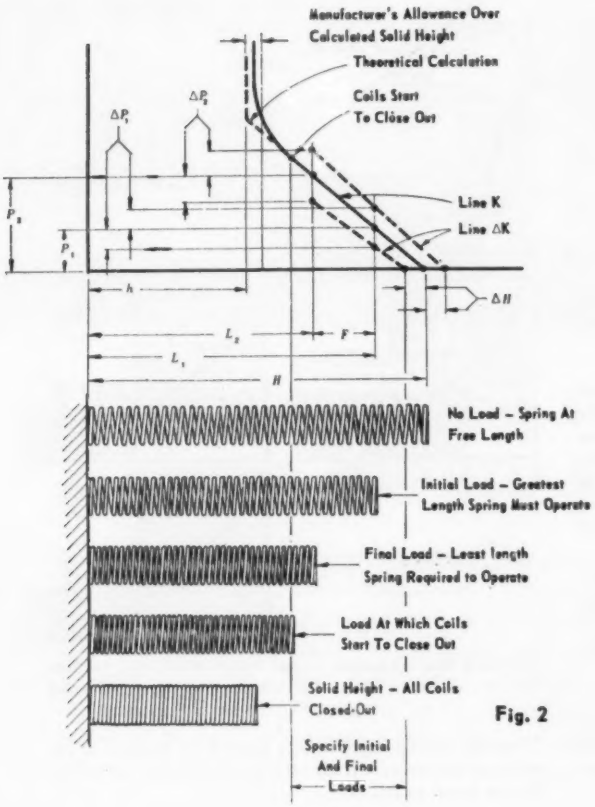
Fig. 1

Helical coil compression springs store energy by being compressed. As load is applied to the spring, the spring reduces in length (L). When permitted to release the energy stored, the spring expands in length and exerts a pushing force.

The relation of the *load* to the *deflection* of the spring is called "gradient" (K) and is defined as "the load required to deflect a spring a given distance". Gradient is usually expressed in terms of pounds per inch of deflection. Further, this relationship can be plotted as illustrated by the sloping straight line in Fig. 1 and by line K in Fig. 2.

The slope of line K can be calculated when certain dimensional characteristics of the spring are known and used. However, since we are not now concerned with calculations or methods, it is sufficient for our present purposes to state that: (1) when the loads desired in a spring are known, the slope of line K can be calculated; or (2) when the slope of line K is known, loads can be calculated.

Referring to the graphical description, note that when no load is applied to a compression spring, the spring does not deflect, stores no energy, and is inoperative. This over-all length of a spring unloaded is called "free length" (H). Like all measurements in any manufactured product, free length will vary in springs. Since this "free length variation" (ΔH) affects other characteristics it must be taken into consideration. For instance, note that when the starting point of the K line differs from that of other similar springs as a result of free length variation, the load (P_1 or P_2) at any desired length (L_1 or L_2) will also vary as shown by ΔP_1 (initial load variation) and ΔP_2 (final load variation). Also, variables in the spring will cause variations in gradient (ΔK) as shown by the difference in slope in dotted lines ΔK.


Manufacturer's Allowance Over Calculated Solid Height
Theoretical Calculation
Coils Start To Close Out
Line K
Line ΔK
No Load – Spring At Free Length
Initial Load – Greatest Length Spring Must Operate
Final Load – Least length Spring Required to Operate
Load At Which Coils Start To Close Out
Solid Height – All Coils Closed-Out
Specify Initial And Final Loads
Fig. 2

As increasingly greater load is applied to the spring, the spring will deflect to a point at which the spring coils start to contact adjacent coils (close out) and become inoperative. When this happens, the operation of the spring is affected and line K can no longer be expressed as a straight line but becomes a pronounced curve as shown. As more and more coils close out, line K continues to curve up. When all of the spring coils close out, the spring has reached its "solid height" (h) and line K becomes a perpendicular line indicating that the spring cannot deflect further. The application of additional force beyond this point would eventually crush the spring.

On the graph, line K is continued as a dotted line. This merely represents theoretical calculation based upon the premise that if a spring could be made perfect in every respect, all coils would close out simultaneously.

From the graphical description, it can be seen that to attain maximum spring effectiveness and test results, "initial load" (P_1) at a desired, "initial length" (L_1) and "final load" (P_2) at "final length" (L_2) should be specified in the lengths between the point at which coils start to close out and the minimum variation in free length of the spring. The range between the operating loads (P_1 and P_2) is called "spring deflection" (F).

The spring application will, of course, determine the deflection and loads required and the other specifications of the spring. This is a part of spring design and will be treated in forthcoming issues.

Courtesy of Spring Division, Hunter Spring Co., Lansdale, Pa.

SPRING DESIGN DATA—4

Compression Springs—the Eight Ways to Specify

In a common door latch, it is important that the spring in the latch have sufficient force at its greatest operating length ("initial length") to keep the latch out when the door is open or closed. In this application, the initial load (P_1) is the most important, or the "primary load". The final load (P_2), the load at the least operating length of the spring, is the less important, or the "secondary load" – the principal limitation being that the final load not be so great as to make operation of the latch difficult.

In other applications, the reverse is often true – the final load might be primary and the initial load secondary.

Compression spring specification should start with the selection of a primary operating load at desired length (P at L), the fixing of a spring deflection (F) and, when required, the determining of second load. This can be done in 8 ways as shown in the illustrations. Case I applies where final load is primary and Case II where initial load is primary.

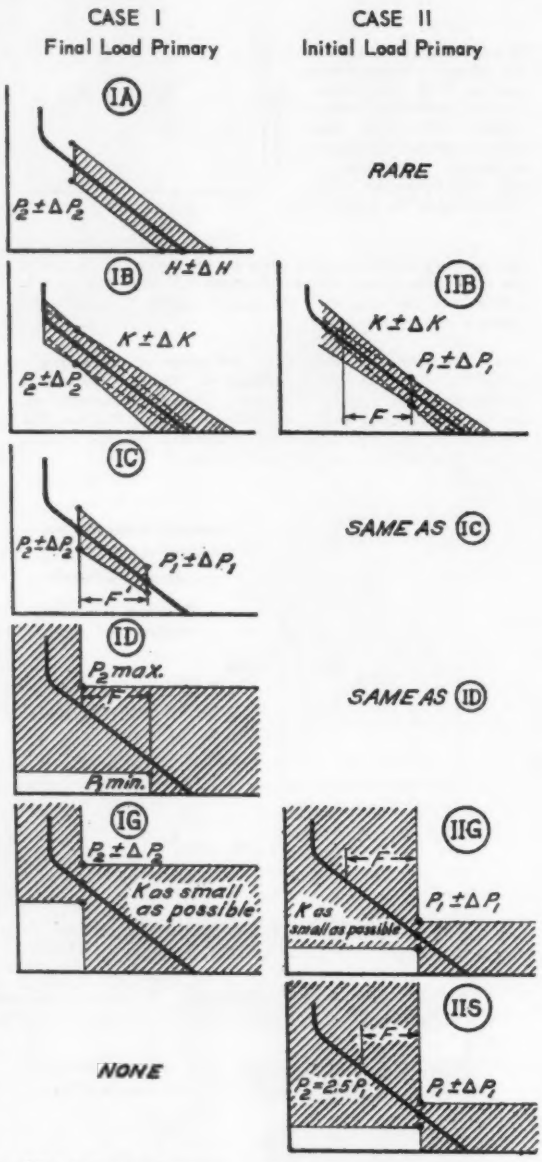
Frequently, only one load is important in specifying a spring. When this is so, a desirable free length should be determined (space requirements taken into account) and the free length should be made the second, required factor for fixing the load-deflection characteristic. This is illustrated in Case IA. Or, an application may be such as to require one important load (primary load) and a specific gradient (K). In this case, the gradient requirements will fix the second load and the spring deflection (F) as shown in Cases IB and IIB.

Sometimes, because of application requirements, it may be desirable to specify a primary and a secondary load. Given these specifications, gradient can be calculated and deflection determined as shown in Case ID.

However, do not make the tolerances for secondary load unduly restrictive because this can involve additional testing and inspection and the use of special manufacturing techniques on the part of the manufacturer which add to cost. For most applications, this can be avoided by specifying maximum allowable final load and minimum allowable initial load as shown in Case ID.

When the application requires the softest possible spring (both loads as close together as possible), the greatest possible free length (H) should be used and the gradient should be as small as possible. Cases IG and IIG illustrate this.

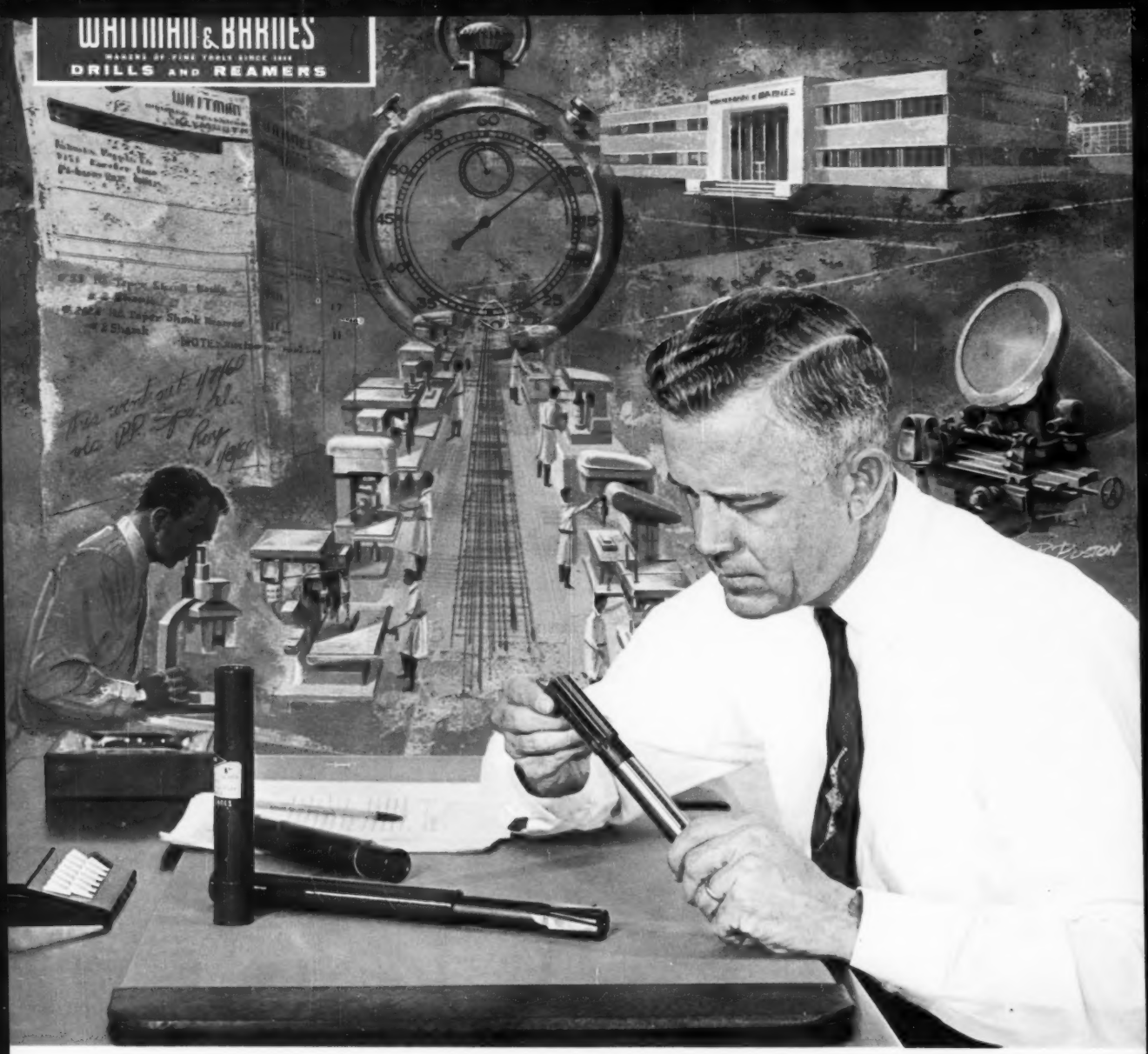
In applications where primary load and a specific additional deflection are required, it is well to design for minimum stress at the final deflection as shown in Case IIS.



(Shaded area represents normal variation (Δ). Any load deflection curve in this area conforms to specifications).

After the spring requirements have been placed in one of these 8 categories, the way will be paved for further design steps to follow.

Courtesy of Spring Division, Hunter Spring Co., Lansdale, Pa.



There's more to the buy than meets the eye

How do I know? We had a finish problem in reaming cast steel. Best finish we were getting was 150-175 micro-inch. We needed 60 or better. A W&B Service Engineer came in with one of their 1-1/16″ Chucking Reamers. He checked feeds and speeds—finally came up with .011 per revolution and 60 SFM. He recommended a secondary grind on the chamfer to assure clearance, then added a second chamfer of 67½°. We were able to get and maintain a reamed finish of 40-50 micro-inches. At the end of the day, the operator was getting all good parts and saving substantial time per piece. In a case like ours, W&B's technical help, service and consistent reamer quality really convinced me that initial price is merely one factor. Find out for yourself . . . test W&B tools in *your* plant under *your* conditions. Call them in direct or through your industrial distributor. Do it today. See if *you* can't get better results.

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DRILLS • REAMERS • END MILLS • COUNTERBORES • COUNTERSINKS • CARBIDE TOOLS • SPECIAL TOOLS

NIKON OPTICAL COMPARATOR

new model 3A offers unusual screen brightness and image resolution – features zoom-condenser system

The unusual image brightness, definition and accuracy achieved in the new model 3A–to the very edge of the screen –is a credit to the quality and design of its optical system.

The new Nikon model 3A permits surface as well as contour inspection–independently or simultaneously. And controls are provided for adjusting the intensity of each of the illuminators.

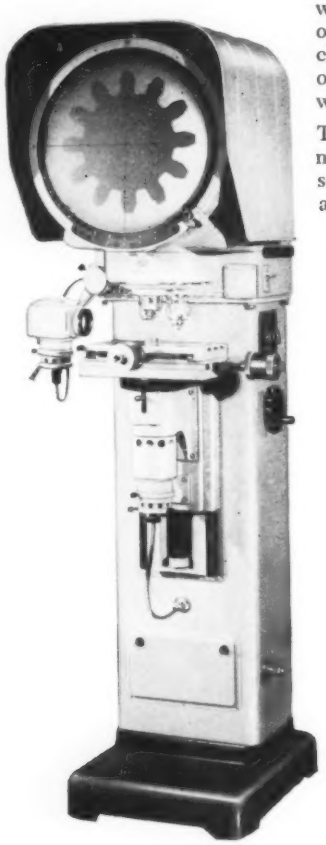
The surface illuminator may be used obliquely to emphasize surface texture. Or, for greater measurement accuracy, the surface illuminator may be used in conjunction with lens-mounted, half-reflecting 45° angle mirrors to provide shadowless light on the optical axis. Contour illuminator employs a special zoom condenser matching system. Convenient control simplifies adjustment for optimum illumination at each magnification.

Model 3A is normally supplied with a choice of one or more standard lenses in magnifications ranging from 10x to 100x. Other magnifications are also available on special order. A 3-lens turret supplied as standard equipment, facilitates instant changes. Focusing is smooth and effortless. Utilizes leadscrew drive with scraped ways and adjustable gibs.

The model 3A is equipped with a sliding hood which may be drawn out to shade the screen, or can be retracted to permit ready access to chart or screen surface. The overall diameter of the screen glass is 14½", designed for use with standard charts.

The new Nikon 3A accepts a wide variety of micrometer stages, holding fixtures, protractor screens, charts, photo attachments, and other accessories. For details write to Dept. M-8.

features new 14" screen



NIKON INCORPORATED Instrument Division 111 Fifth Avenue New York 3, N. Y.

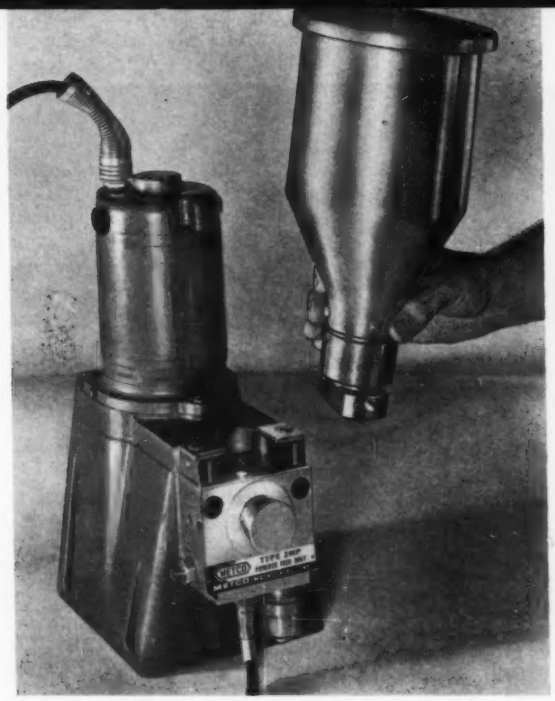
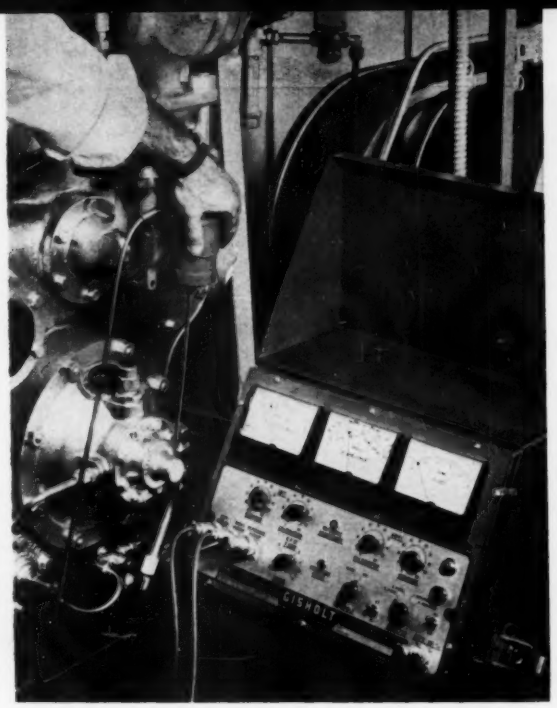


Fig. 1. Powder-feed unit for Metco plasma-flame spray system is removable with twist of the wrist



Gisholt portable balancing unit with inertial type pickup especially designed for maintenance work

Improved System for Precision Plasma Spray Coating

Major improvements in applying plasma spray coating, notably in control and flow of plasma powders that permit exact duplication of coatings, are said to be possible with a new system and equipment announced by the Engineering Division of Metco, Inc., Westbury, N. Y. The system has three components: console, with automatic controls, including fail-safe devices; powder feeder unit (Fig. 1) for accurate duplication of coatings; and simplified spray gun (Fig. 2) with one-piece nozzle and all-purpose electrode, both in fixed positions that eliminate need for adjustment. The system permits flame-spray speeds with most materials of 5 to 15 pounds per hour, with deposit efficiency of 65 to 80 per cent. Tungsten carbide, for instance, has a deposit efficiency of 75 per cent.

Fig. 2. New plasma-flame spray gun announced by Metco, Inc.

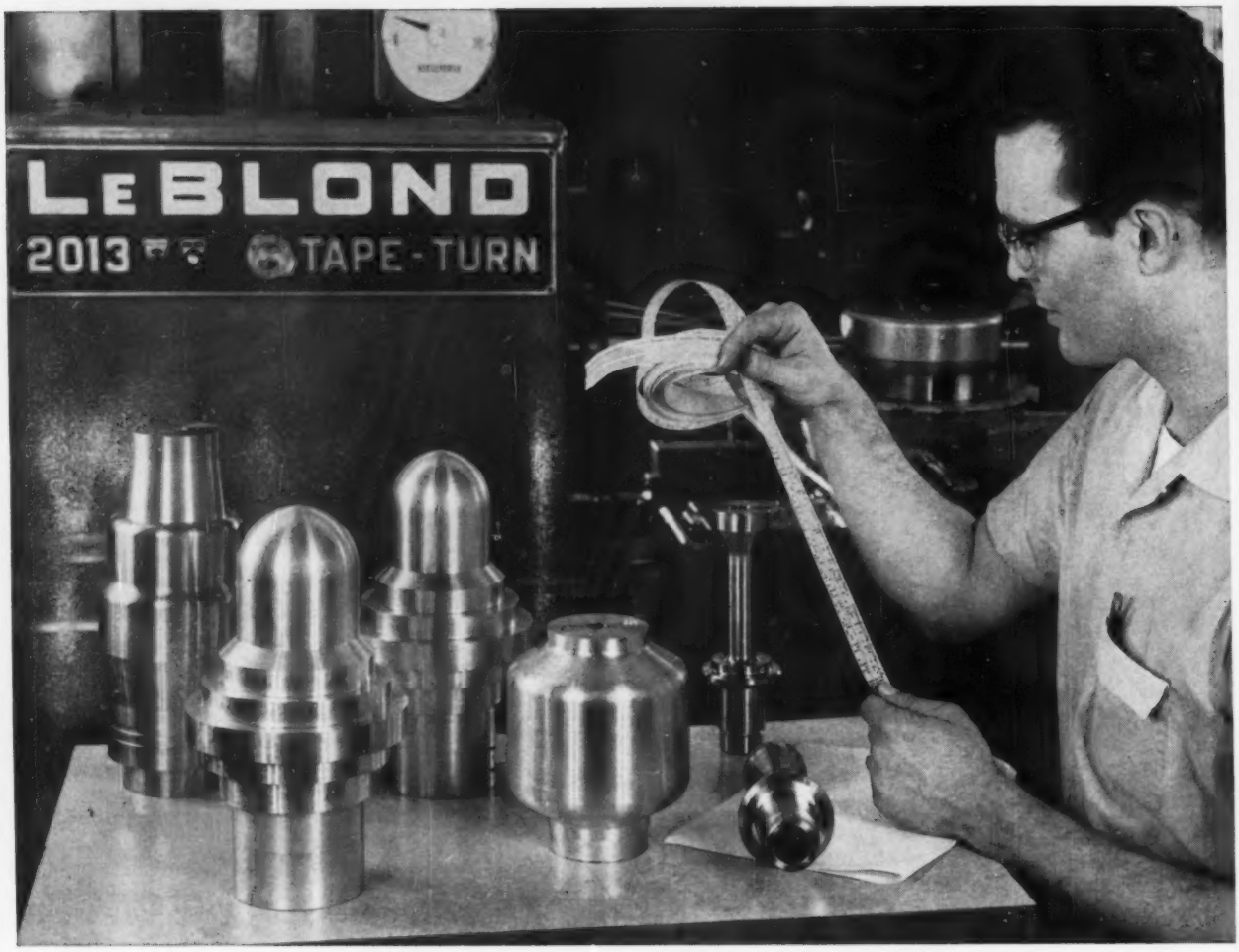
The gun consists mainly of six interchangeable, precision-made parts and a handle. It is light enough (3 1/4 pounds) to be operated by hand, sturdy enough to be machine-mounted, and small enough for spraying internal bores down to an inside diameter of 5 inches. Nitrogen, argon, or helium can be used as the plasma gas. The gun has no moving parts and requires no adjustments. There are no soldered joints exposed to heat. Nozzle and electrode positions are fixed and foolproof. Tap water, at ordinary pressure, is used as a coolant, and no heat exchanger is required.

Eighteen or more materials and mixtures have been sprayed with the standard apparatus on various-shaped objects and mandrels and are now available. These include materials with melting points ranging from 2650 degrees F., for nickel, up to 6170 degrees F., for tungsten. Aluminum oxide, calcium zirconate, chromium, chromium carbide, cobalt, magnesium zirconate, molybdenum, titanium oxide, zirconium silicate, and rare-earth oxides are among the materials being successfully used in the new equipment for plasma spray coating. Physical and metallurgical properties of the coatings are said be superior.

Circle 575 on Readers' Service Card

Portable Unit for Maintenance Balance

The Gisholt Machine Co., Madison, Wis., recently added a transistorized portable balancer to its line of balancing machines. This balancer features building-block design and selector-switch operation to provide direct, usable answers for the large variety of vibration and balancing problems occurring in rotating members of various assemblies or permanent installations. Small size and light weight make it ideal for on-location use in preventative maintenance programs designed to eliminate the harmful effects of unbalance in rotating components.



Turn your parts profitably

For turning complex contoured parts, in job lot quantities, Tape-Turn will show you rock-bottom costs! Its continuous path Mark Century tape control puts engineering data at the cutting edge far more efficiently than any manual or tracer turning method.

Because LeBlond pioneered continuous-path turning with tape, you'll benefit by many months of experience. We can show you actual applications on production runs. Our skilled programming staff will help your engineers learn the simple routines involved in tape turning.

Simple programming is a major feature of LeBlond Tape-Turn. The General Electric Mark Century control has a built-in computer which saves the programmer time in setting up for straight cuts, tapers, arcs and blended combinations of these. For the most complex shapes, separate computer assistance is desirable. You can learn the Tape-Turn programming procedure in half a day!

Increased efficiency, reduced lead time, a permanent record in easily stored form, low-cost quality control, reduced parts inventory, shorter set-up time and lower tooling costs—plus all the reliability and precision of a LeBlond Heavy-Duty Lathe—these are yours with LeBlond Tape-Turn. Write for descriptive bulletin TWH.

Look at these savings!

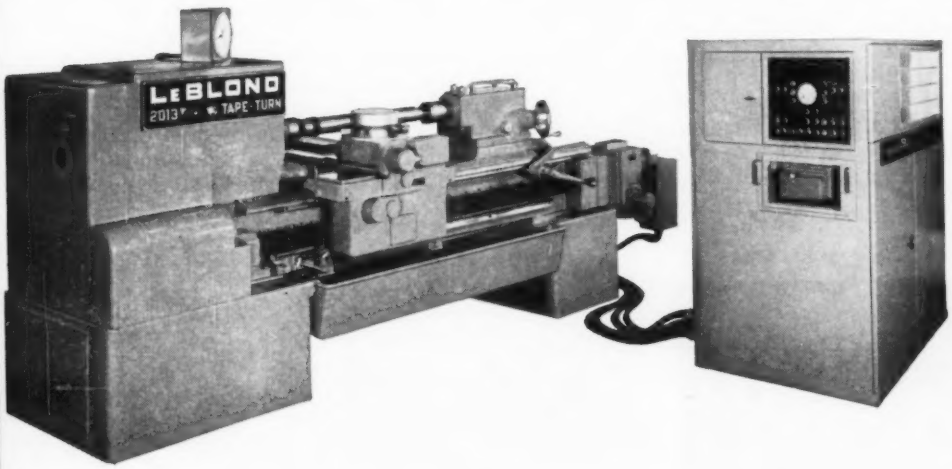
This cluster gear blank, used in a jet engine, is machined in lots of 100. Formerly turned on a production copy lathe, total time—including template preparation and set-up—was 2950 minutes. On Tape-Turn, total time is 992 minutes, including programming, tape preparation and set-up.

Savings—66.3%!

In lot size of just six, this contoured shaft was machined on a tracer lathe in a total of 1763.7 minutes. This includes time for preparation of the template and set-up. LeBlond Tape-Turn slashes the total to 759.6 minutes, counting programming, tape preparation and set-up.

Savings—57.7%!

-on LeBlond Tape-Turn



In production, now.
Eight Heavy-Duty Models: 2013, 2516 and 2516-20 NE, 20 hp. 2516, 3220 and 3220-25 NF, up to 50 hp. 4025 and 4025-32, up to 75 hp.

"Leading the way in numerically controlled turning"

LEBLOND of Cincinnati

The R. K. LeBlond Machine Tool Company
Cincinnati 8, Ohio

For more data, circle this page number on Readers' Service Card.

The Gisholt Masterline portable balancer is not designed for production balancing operations. It can be used to advantage, however, in permanent installations in test stands at oil and chemical plants which house numerous large rotating elements. The test stands need be no more complex than a spring-mounted plate upon which the assembly being tested rests.

Greatly simplified procedures are possible, with force (single-plane) and moment (two-plane) indications provided for use in large buildings, ships, and even aircraft where periodic balancing of large blowers and other permanently installed rotating elements is necessary or desirable. Machine manufacturers can use the portable balancer to check rotating assemblies where vibrations need to be isolated, measured, located, and corrected. Other application areas include certain types of automotive repair stations and commercial garages. The portable balancer can also be used as a "built-in" monitoring device in certain facilities.

Four different amplifier and control unit combinations of building-block design are offered. The simplest consists of a vibration-amplitude indicator and filter for monitoring use. Next is a unit with a vibration-amplitude indicator, filter, angle (phase) meter, and tachometer for single-plane checking and correcting. The third includes a vibration-amplitude indicator, filter, plane separation networks, and calibration controls for two-plane operations. The most universal unit (illustrated) houses three meters (angle, amount, tachometer), a filter control, left- and right-plane separation networks and controls, an angle-phasing switch, and a selector switch. This last-mentioned unit can be used for all types of single- and two-plane operations. Five different filter arrangements are offered so that units can be set up to cover various operating-speed increments within an over-all range of 300 to 150,000 cycles per minute. A wide range of accessories is available for adapting the units to practically any balancing requirement. Sensitivity is such that vibration amplitudes as small as 0.000025 inch can be measured, located, and corrected. The units are completely transistorized and use printed circuits for maintenance-free operation.

Circle 576 on Readers' Service Card

Cone Drill for Producing Variety of Hole Diameters in Thin Materials

Lower tool costs, fewer tool changes, and elimination of separate finishing steps in some drilling operations are advantages claimed for a new cone drill developed by Scully-Jones & Co., Chicago, Ill. A single drill produces a wide variety of hole diameters in metal, plastic, or any other relatively thin material. Tool-change time and need for stocking a variety of drill sizes are eliminated. It drills any hole size from 1/4 to 1 1/4 inches in diameter and has a 7/32-inch diameter drill point which eliminates the necessity for punching or drilling a starting or center hole in work.

The cone drill is furnished with a straight shank 3/8 by 1 11/16 inches, a flute length of 2 3/4 inches, and an over-all length of 4 7/16 inches. The body is 1 3/8 inches in diameter at the large end and has a 25-degree included angle. Cone drills can be used in power tools of 1/2-inch drill capacity, in drill presses, and similar machines. The recommended speed after the hole is started is 500 to 600 rpm. Speed for starting a hole can be much higher to suit the small diameter of drill point.

Circle 577 on Readers' Service Card

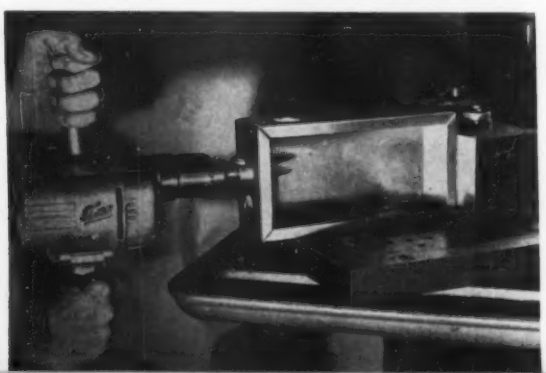
Precision Index-Center

Finer tolerances in inspection of work on centers, and in jig-boring, milling, and jig-grinding work performed on centers, are said to be assured through the use of a precision index-center produced by the Moore Special Tool Co., Inc., Bridgeport, Conn. This index-center is designed to achieve peak precision on form grinding of spiders, splined punches, gear die punches and dies, and sectional parts of dies which must be revolved on centers or a spindle.

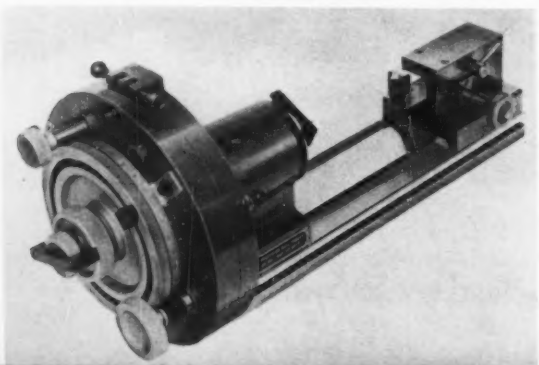
Major features include a special ball-construction spindle; lapped-fit, 192 balls plus or minus 0.000005 (5 millionths) inch tolerance under load; runs true to 0.000015 (15 millionths) inch true indicator reading; also a lapped carbide index plug and four lapped-fit carbide plug-in stations. The extra plug-in station allows the user to turn his work-piece exactly 180 degrees at any time to locate it on dead center. The plug-in station can also be used to reorient the work for a different set of angles. There is an accurately adjustable tailstock, and center line-up is maintained with lapped-fit ram movement of center. Offset tailstock construction allows clearance for wheel when slot grinding. Sealed against dirt, the Moore precision index-center can also be used in wet grinding.

Circle 578 on Readers' Service Card

Scully-Jones cone drill for thin materials



Moore precision index-center for inspection work



.0003″ SPHERICITY

from cold-headed to finished surface

. . . in just <u>two</u> operations

True sphericity, with closer control of size and surface finish than previously possible, is accomplished in only two cost-cutting operations by the new Micromatic process for machining truncated spheres.

The only machining operations on the spherical end are milling and Microhoning. Combining new techniques with specially developed spherical milling and Microhoning machines, the process generates sphericity within .0003″ tolerance and a controlled microinch finish of 6-10 rms. (Former methods were hard pressed to productively obtain sphericity within .002″.)

All the machining and polishing operations—such as turning, grinding, buffing—which old processing methods required on the spherical end are eliminated. Also, some operations on other parts of the workpiece (e.g., turning and grinding of the taper shank) are no longer necessary.

The new method can be applied to any truncated sphere which has a shank or bore to permit holding without touching the sphere. Micromatic will be happy to show you the dramatic savings being enjoyed by leading production plants using its spherical process.

Shown at left is a clutch release lever before and after spherical milling. In this case, accuracies and surface finish milled are perfectly satisfactory for assembly without further processing of the sphere.

MICROMATIC HONE CORPORATION

8100 SCHOOLCRAFT • DETROIT 38, MICHIGAN

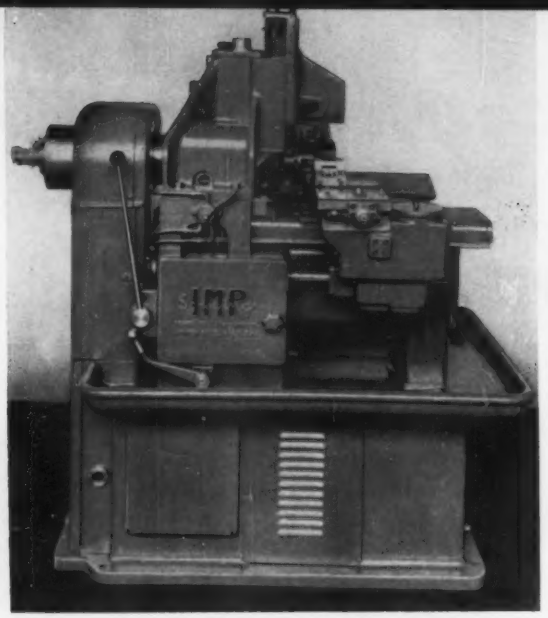


Fig. 1. Lo-Swing automatic IMP lathe equipped to process diesel-engine injector nozzles

Redesigned angle-roll unit announced by the Kling Division of Hill Acme Co.

Lo-Swing Automatic Lathes Equipped to Machine Diesel-Engine Injector Nozzles

The extremely close tolerances and fine finishes required on diesel-engine injector nozzles are being obtained at high production rates by performing the outside finishing operations on two Lo-Swing automatic IMP lathes built by the Seneca Falls Machine Co., Seneca Falls, N. Y. Traditionally, these parts were formed on multiple-spindle machine tools. They require three machining operations: (1) rough-form and finish-form a 10-degree ± 30-minute angle to a 0.382- to 0.383-inch diameter, (2) finish-form 0.040- to 0.030-inch nose radius to 0.998- to 0.996-inch diameter, and (3) finish-form a 30-degree ± 5-minute angle to a 0.533-inch reference dimension. Following these operations, the tip of the nozzle is drilled with a series of angular holes to complete the piece. Because of the extremely small diameter (0.007 inch) of these holes, the surface must be completely free from any turning marks to prevent deflection during drilling operations, which would result in scrapping of the work-piece.

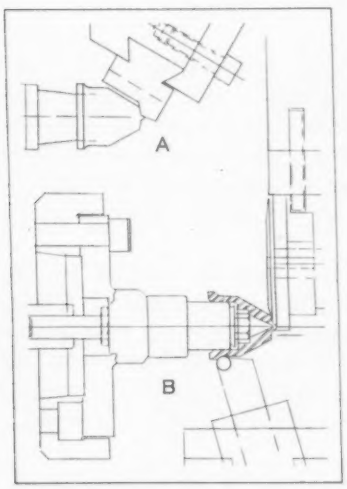


Fig. 2. (A) Top slide, utilizing a dovetailed form tool, rough-forms the 10-degree ± 30-minute angle and roughs nose radius of injector nozzles. (B) Back slide with circular form tool finishes angle and tip. Front, template-controlled slide finish-generates 30-degree ± 5-minute angle to a 0.533-inch reference dimension

All three machining operations are now performed in one continuous automatic cycle on the Seneca Falls lathes with production rates of 150 pieces per hour per machine. The IMP lathes are equipped with three slides—a top, front, and rear. The automatic machining cycle starts at low speed (1800 rpm) with the top slide, utilizing a dovetailed form tool, which rough-forms the 10-degree ± 30-minute angle and roughs the nose radius. Then the back slide, with a circular form tool, finishes the angle and the tip. At this point the machine kicks into high speed (3600 rpm) and the front, template-controlled slide approaches the work-piece and finish-generates the 30-degree ± 5-minute angle to a 0.533-inch reference dimension. The machining cycle is completely automatic; the operator simply loads and unloads the nozzles and pushes the starter button.

The automatic IMP lathe, with a work-piece capacity of up to 12 inches in length, is capable of extreme accuracy, and incorporates many design features normally found only in larger, more expensive machines. Operation of the machine is entirely mechanically controlled by cams. Spindle speeds are modified by changing pick-off pulleys which are easily accessible and may be changed without removal of air cylinder and other attachments.

Circle 579 on Readers' Service Card

Kling Pyramid Type Angle Roll

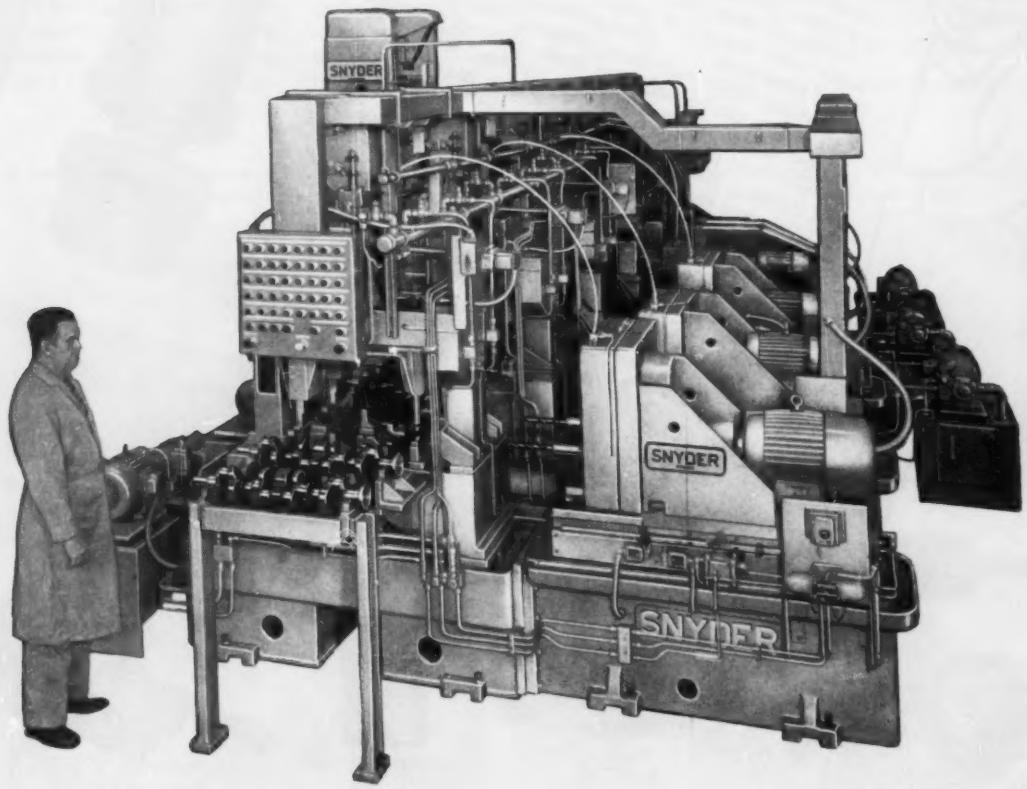
The Hill Acme Co., Cleveland, Ohio, which is now manufacturing and selling the entire line of Kling metalworking tools, has completely redesigned the Kling Pyramid angle roll. This new unit, which rolls angles, channels, flat bars, etc., is made in several sizes

OVERSEAS CAR BUILDER ADDS ANOTHER SNYDER TRANSFER MACHINE IN FURTHER MOVE TO CURTAIL COSTS

Intensified competition for world markets brought back this old friend of Snyder products seeking further relief from manufacturing cost and labor problems. The answer to this specific problem is a Snyder Special 20-station, building block transfer machine that drills, reams, taps, chamfers and precision-bores 78 automotive engine crankshafts per hour at 100% efficiency.

The overseas customer for whom the machine was built came to the U. S. and, specifically, to Snyder for this cost-cutting, labor-saving machine because of the availability of definite benefits. These include previous experience of Snyder's ability to successfully adapt high-production, cost-cutting techniques to limited production quotas, long experience exclusively in the special machine tool field, domestic and export, and appreciation of Snyder's fresh and creative approach to *any* production problem. There were also the factors of Snyder's engineering and plant resources, assuring fast action and a delivery schedule probably not possible outside the U. S., and the availability of Snyder's standard units, pre-engineered and widely applicable. These same advantages are available to you. We'd like to hear from you.

SNYDER
CORPORATION
3400 E. LAFAYETTE—DETROIT 7, MICHIGAN
Phone: LO 7-0123



For more data, circle this page number on Readers' Service Card.

GOOD NEWS FOR COST MINDED TOOL ENGINEERS

STANDARDIZED UNIVERSAL INDEX PLUNGERS COST 75% LESS THAN SPECIALLY-MADE TOOL ROOM PLUNGERS

In jig or fixture manufacture, it's both expensive and time-consuming to design and machine special index plungers for multi-station tools. To save time and money use Universal Straight or Taper Plungers. They are made in standard sizes . . . come complete, ready for installation . . . at approximately ¼ the cost of specially made tool room plungers. Universal Index Plungers can be assembled from either top or bottom and can be removed in either direction. Because the Universal plunger body and bushing have the same standard diameter . . . all holes can be bored with the same tool, simplifying drilling of jig or fixture in fabrication.

Universal Index Plungers can be actuated by either hand lever or air cylinders for automatic indexing tools. The locating bushing, plunger and plunger bushing are hardened and ground . . . precision built for extreme accuracy and long wear. Write for catalog detailing plungers plus other Universal production tools.

OTHER PRECISION-BUILT COST-SAVING UNIVERSAL PRODUCTION TOOLS

211

Floating Chuck

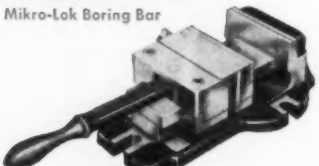
Standard Collet Chuck

Mikro-Lok Boring Bar

Boring Chuck

"Kwik-Switch" Tool Holder

Standard Drill Bushing



Wedge-Lock Production Vise

UNIVERSAL ENGINEERING COMPANY, FRANKENMUTH 2, MICHIGAN

to accommodate all normal industrial and construction needs.

The principal features are welded-steel construction, with a totally enclosed worm-gear drive, and a power-elevating screw running on antifriction bearings. These units are self-contained. The size (1/2-A) illustrated here has a rolling speed of 30 fpm; weighs 9000 pounds; and has a capacity of 3 1/2 by 3 1/2 inches by 3/8 inch in angles, 6- by 1-inch flat bars, and 6-inch 13-pound channels. A 10-hp, variable-speed wound-rotor motor is standard equipment.

Circle 580 on Readers' Service Card

Broaching Machines for Automated High-Production Operations

The General Broach & Engineering Co., Detroit, Mich., has brought out a line of standard, press type broaching machines for completely automatic, heavy-duty high-production applications. Six standard models cover a normal operating capacity range of from 4 to 15 tons, with a stroke span of 22 to 36 inches. A stroke-control limit switch permits accurate stroke adjustment. Standard features include a hydraulic pump, an extra-large (100- to 140-gallon capacity) tank, and a heavy-duty motor, all externally mounted as a separate unit.

All models are equipped with a four-way guided ram. "Open-knee" platen and pot type chambers facilitate installation of automated loading and unloading equipment. Quick, easy conversion to push, surface, straddle, and other types of broaching, plus a selection of various shapes and types of platens, gives versatility.

Circle 581 on Readers' Service Card

Optical Comparator Designed for Extra Measuring Accuracy

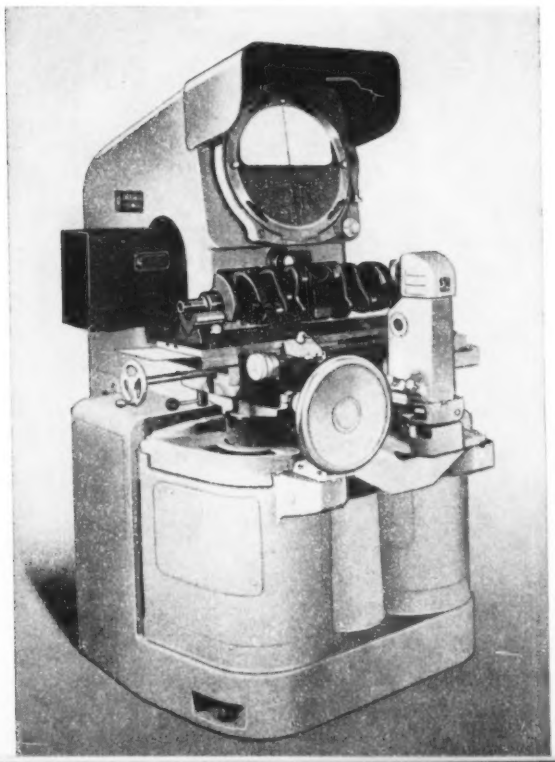
A 14-inch screen optical comparator and measuring machine, Model FC-14ER, which is particularly applicable to the inspection of such parts as lead-screws, die bodies, castings and forgings, large circuit boards, etc., has been announced by the Jones & Lamson Machine Co., Springfield, Vt. The work-table of this comparator is 32 inches long, 8 inches wide, and is supported on two heavy-duty columns having 10-pitch hardened and ground lead-screws. This rugged double-spindle construction provides extra stability for motion of large, heavy workpieces, both laterally and vertically to assure high accuracy.

The machine is equipped with the Jones & Lamson Telecentric optical system, which provides projection lenses that are matched and preset for exact rated magnification on master optical benches. No adjustments are necessary when changing magnifications.

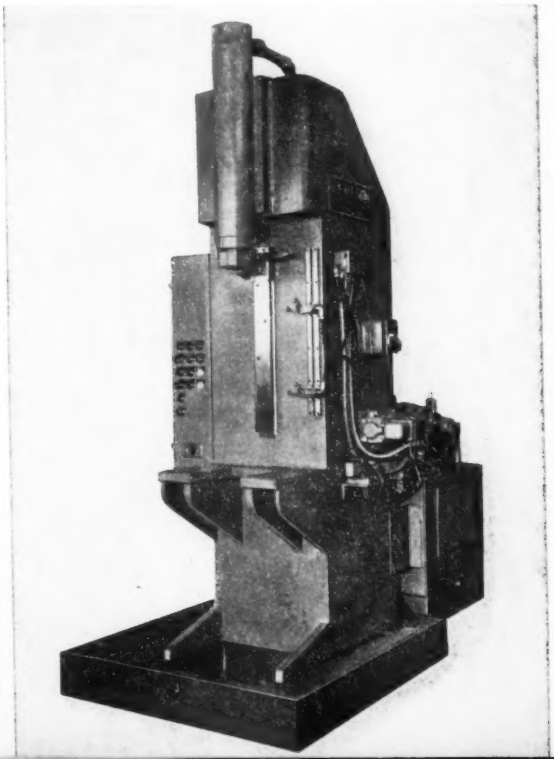
Features available with this model include: electronic variable-speed power elevation, variable light-intensity control, six-position automatic indexing lens selector, normal reflection unit, tracing attachment, and vertical illumination and staging equipment.

Circle 582 on Readers' Service Card

Jones & Lamson optical comparator equipped with Telecentric optical system having matched lenses



High-production automated broaching machine brought out by General Broach & Engineering Co.



NEBUCHADNEZZAR WENT BEYOND USUAL PRACTICE -- SO DOES LAMB

In its time the Hanging Gardens was a monument to a king's sentiment—a marvel of expression in terms of imagination and creative engineering. Nebuchadnezzar, one of the greatest builders the world has ever known, went far beyond usual practice to accomplish his special purpose and thus gave us one of the "7 Wonders of the Ancient World."

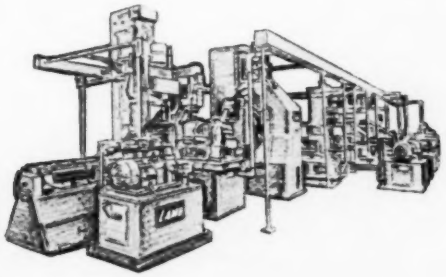
From ancient times to the present, imagination, creativity and sound technical background have been the principal factors in every outstanding engineering achievement. At Lamb these factors are applied to the design and construction of production machinery and equipment. Lamb goes beyond "usual industry practice" to provide something extra in methods, reliability, performance and manufacturing economy.

Be sure to investigate the benefits you get from putting Lamb experience and creative engineering to work on your manufacturing problems.

Hanging Gardens of Babylon

On the hot Mesopotamian plain, not far from the Tower of Babel, King Nebuchadnezzar (605 to 526 B.C.) built the sumptuous gardens to please his wife, Queen Semiramis, who longed for the mountains and fertile valleys of her native Assyria. Five terraces, each 50 feet above the other were covered with deep loam to support trees, plants and tame animals from the forest. An irrigation system drew water from the Euphrates to supply the fountains and feed the soil. After Babylon was taken by the Persians, the city sank into ruin and was covered by desert sands.

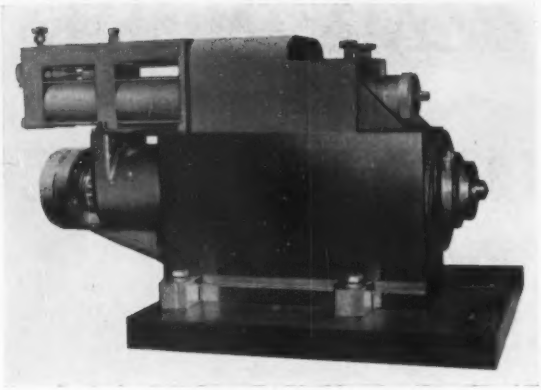
One of a series of paintings by Mario Larrinaga, commissioned by F. Jos. Lamb Co. Copies suitable for framing available on request.



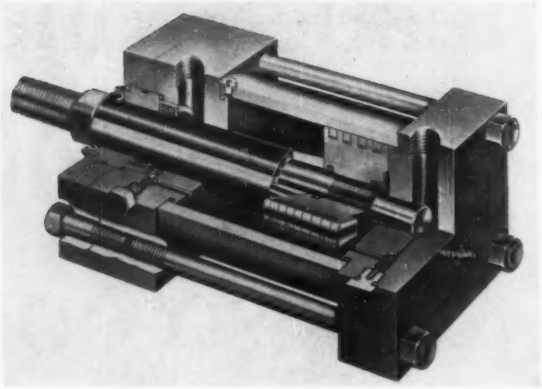
F. JOS. LAMB CO.

5663 E. NINE MILE ROAD • DETROIT 34, MICHIGAN #9726

Since 1914 Engineers and Builders of Special Machines and Automation Equipment



Whitnon miniature precision boring equipment



Sheffer interchangeable hydraulic cylinder

Precision Boring Assembly

A complete miniature precision boring spindle assembly for use in the instrument and small-parts industries has been developed by the Whitnon Mfg. Co., Farmington, Conn. A reciprocating boring spindle with up to 2 inches of axial travel, it has exhibited a rotational error of less than 0.00003 inch (30 millionths inch) and a travel error of less than 0.00005 inch (50 millionths inch) in its entire range of travel. Equipped with micrometer depth control, it repeats to within 0.0002 inch, with fast infeed, controlled boring feed, and dwell time all precisely variable.

Boring speeds range from 1000 to 15,000 rpm. By using several units as modules or building blocks mounted on a surface plate, multiple directional miniature boring machines can be assembled, and revised for changing needs, at modest cost.

Circle 583 on Readers' Service Card

Interchangeable Hydraulic Cylinders

An improved new series of interchangeable hydraulic cylinders with bores ranging from 1 1/8 through 14 inches in diameter, with eighteen mountings for operation at pressures up to 3500 psi, is announced by the Sheffer Corporation, Cincinnati, Ohio. Known as Sheffer's HH series, these rugged cylinders meet or exceed JIC standards. They feature tie-rod construction for maximum strength and shock loading; have long-wearing, easily maintained rod cartridges; are removable with a wrench; and have four different types of piston packing for various applications.

Heads, retainers, and mountings are of machined steel. Cylinder tubes are micro-finished seamless steel, sealed with O-rings placed to completely eliminate "extrusion." Piston rods are 110,000-psi high-tensile steel, hard chromium-plated by a special process to insure the smoothest possible surface and excellent corrosion resistance.

Rod wipers are of Teflon, designed to keep rods clean and dry for maximum service life. Rod packing is of the low friction, self-adjusting, long-wearing multiple-lip type. Pistons are one-piece, fine-grain alloy cast iron, threaded and pinned to the rod. Sheffer "tapered cushions" eliminate cushion-adjusting screws, provide positive gradual deceleration, and eliminate shock upon entrance of cushion piston. SAE straight-thread O-ring sealed ports, offering positive seal with full thread engagement, may be had at no extra cost.

Circle 584 on Readers' Service Card

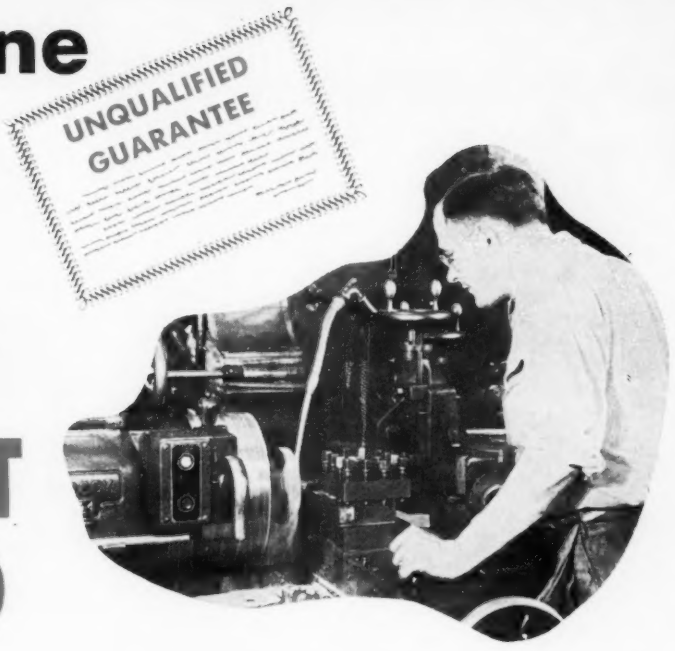
Williams' new wide-range, versatile Combo socket set

"Combo" Socket Set

J. H. Williams & Co., Buffalo, N. Y., has brought out a "Combo" socket set designed to combine convenience, efficiency, and economy. It is said to feature more drive power and versatility than preceding sets twice its size. With only seven basic driver parts, the mechanic can make hundreds of different drive combinations ranging from a flexible ratchet head to a sliding T-bar. Eleven socket sizes range from 3/8 to 1 inch, in increments of 1/16 inch. The sockets are made by Williams' newly developed cold impact extrusion process. Extremely close tolerances, improved concentricity, and great strength combine to provide maximum tool power in these sockets.

Circle 585 on Readers' Service Card

here's the one SOLUBLE CUTTING LUBRICANT that WON'T GO RANCID



and it's backed by an UNQUALIFIED GUARANTEE

We absolutely GUARANTEE that MACCO 472 MPA will not turn rancid under any circumstances. We are the only manufacturer of soluble cutting lubricants who can make this Guarantee.

IT'S MACCO 472 MPA*

Ideal for MACHINING ALL METALS ON ALL TYPES OF EQUIPMENT

THERE'S NOTHING ELSE LIKE IT!

Hard to believe? You bet! But, it's a fact—backed by experience. One plant with hundreds of machines down 70 days, another 116 days, still another for 6 months (names will be furnished on request) —all started up with the same MACCO 472 MPA solution that was in use when they shut down, and ABSOLUTELY NO TRACE OF RANCIDITY IN ANY MACHINE!

With vacation shutdowns coming now is the time to make the change to MACCO 472 MPA. Save yourself a lot of headaches, and some hard earned maintenance dollars to boot. Write or Phone Today for a Macco engineer. He'll give you facts, and make it possible for you to prove for yourself why MACCO 472 MPA is today's No. 1 soluble cutting lubricant in plant after plant. When vacation is over you'll start up with no worry . . . NO RANCIDITY!

And, in addition, **WE GUARANTEE TO INCREASE YOUR TOOL LIFE 25%, or more!**

***An Exclusive Development**

472 MPA is one more of many reasons why

THE METALWORKING INDUSTRY LOOKS TO MACCO FOR LEADERSHIP

CLEANING COMPOUNDS
CUTTING LUBRICANTS

DRAWING COMPOUNDS
RUST PREVENTIVES
FORGING COMPOUNDS
EXTRUSION LUBRICANTS

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CHEMICAL COMPOUNDS

FOR THE METALWORKING TRADE SINCE 1921

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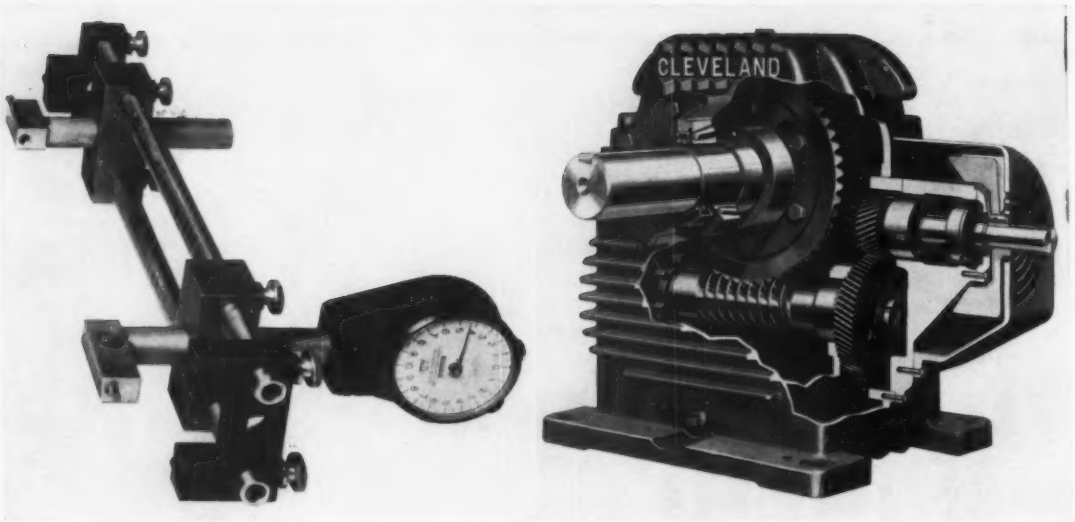


Wright versatile dial gage with heavy-duty basic frame Cleveland fan-cooled helical worm-gear speed reducers

Multiple-Spindle Drilling and Tapping Heads with Individual Spindle Lead-Screws

Zagar, Inc., Cleveland, Ohio, can now incorporate individual spindle lead-screws on their drilling-tapping heads. With these heads simultaneous tapping of holes with as close as 5/16-inch centers is possible. Spindle lead-screws are designed to operate on the same close centers as the spindles to which they are attached. The new standard will allow Class 3 threads to be tapped consistently in all materials.

Generally, a new flexibility is now possible with multiple-spindle lead-screw tapping. Along with the new spindle lead-screw standards, Zagar has available individual lead-screw tapping units with single- or multiple-speed drives. The accompanying illustration shows a spindle lead-screw head containing seventy-three spindles with 32-, 40-, 48-, and 56-pitch leads.

Circle 586 on Readers' Service Card

Zagar drilling and tapping head with individual spindle lead-screws

Dial Gages With Building-Block Accessories

Wright Gage Inc., Kingston, N. Y., has brought out an attractive heavy-duty basic gage frame. With the frame, a multitude of various gaging operations are possible through the selection of three interchangeable gaging heads—a right-angle, direct-reading, and depth head.

Fully adjustable, each assembly has a depth adjustment of 0 to 2 inches. The gaging diameter is adjustable from 3 1/2 to 16 1/2 inches inside diameter, and from 0 to 13 inches outside diameter. All horizontal adjustments are facilitated by knurled thumb lock screws. Guide rails are polished stainless-steel thick wall tubing.

Dial indicators are enclosed in a protective housing, and rotatable 360 degrees. "C" size indicators are used, with a choice of graduations: 0.001, 0.0005, and 0.0001 inch. Modifications to the basic frame and the three gaging heads can be specified by customer.

Circle 587 on Readers' Service Card

Helical Worm-Gear Speed Reducers

Fan-cooled helical worm-gear speed reducers are available in ratios between approximately 34 to 1 and 394 to 1 from the Cleve-

MICRO Sure

...the completely new

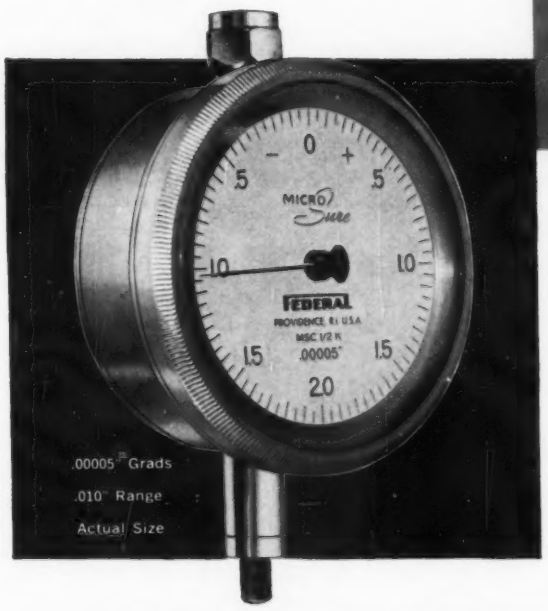
DIAL INDICATOR

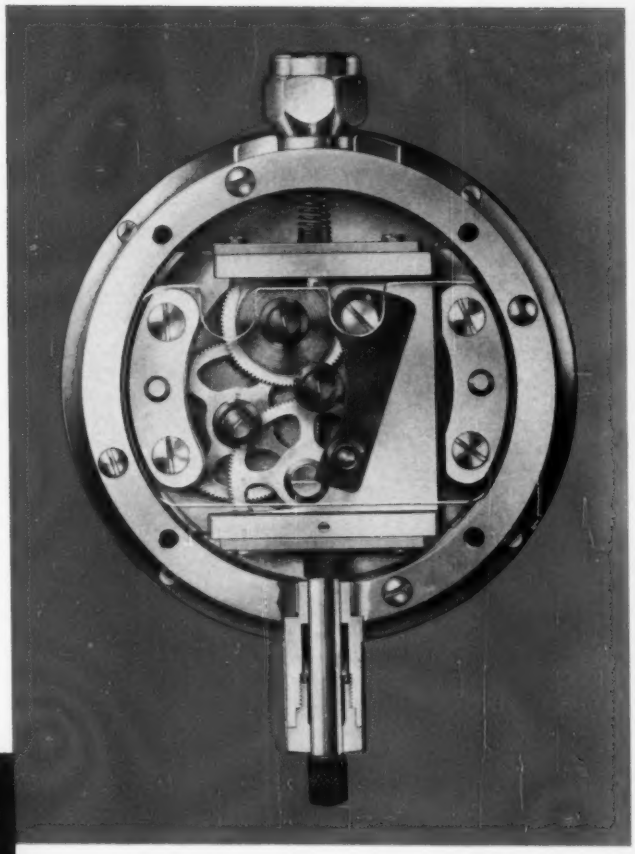
MORE COMBINED ACCURACY AND CONTINUOUS OPERATING RANGE

...than any Electronic Gage

...than any Air Gage

AT A FRACTION OF THE COST!





No dimensional indicators you have ever known can be compared to the MICRO-SURE Indicator because it represents an *entirely new concept* in indicator design . . .

- a design which provides high magnification (.000050" grads) over the FULL AGD range with two to four times the calibration and repeat accuracy of conventional indicators.
- a design which provides repetitive accuracy to within FIVE MILLIONTHS of an inch!
- a design which provides a total allowable calibration error of only FIFTY MILLIONTHS of an inch over the FULL AGD RANGE!
- a design which provides POSITIVE PROTECTION for these exceptional accuracies against shock . . . against wear!
- a design which wholly prevents stem bushing play from having any effect on accuracy!

The MICRO-SURE Indicator makes possible for the first time, such highly accurate, reliable performance in the *shop* as well as in the gage lab, that even *we* probably do not fully appreciate its great potentialities as a comparatively low priced instrument of extremely high precision.

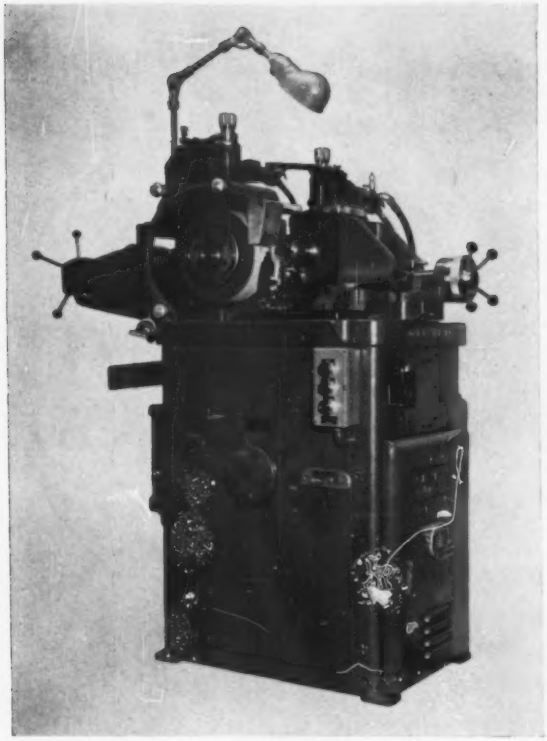
Get the whole story . . . write for brochure.

FEDERAL PRODUCTS CORP.
1118 Eddy Street, Providence 1, R. I.

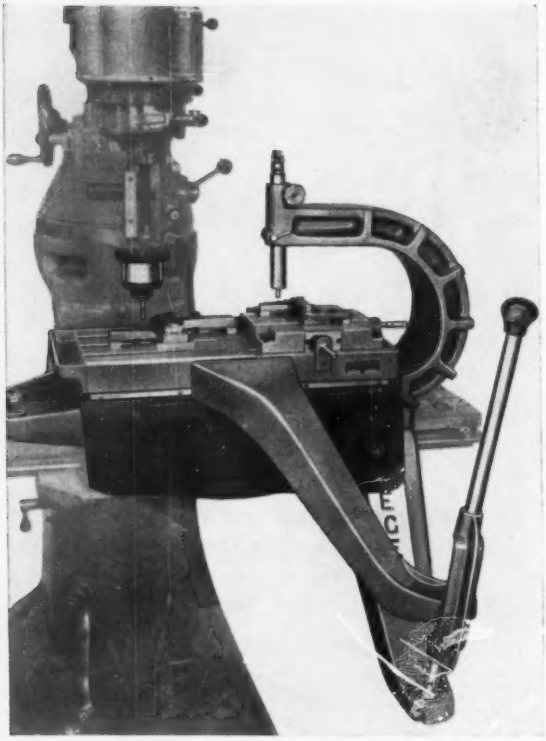
Ask **FEDERAL**® *First*

for recommendations in modern gages . . . Dial Indicating, Air, Electric, or Electronic — for Inspecting, Measuring, Sorting, or Automation Gaging.

For more data, circle this page number on Readers' Service Card.



Precision grinder built by Royal Master Grinders, Inc.



Regent two-dimensional fluid-motion duplicator table

land Worm & Gear Division, Eaton Mfg. Co., Cleveland, Ohio. The reducers come in seven sizes with center distances ranging from 4 to 12 inches. Ratings range from fractional to 58.5 hp.

The helical primary gears of these reducers are cut from high-hardness steel. In the secondary reduction, worms are machined from medium-carbon steel hardened by the "Flamatic" process, which results in a high degree of hardness to well below the root diameter, while maintaining the advantage of a core of medium strength. For increased wear and fatigue resistance, the worm-gears are cut from bronze of a high tin-copper content and are bolted or keyed to cast-iron hubs.

On larger sizes, both primary and secondary gear trains share a common housing, while separate housings are used on 4- through 6-inch sizes. In all sizes, both gear reductions share a common oil bath. Shafts are supported by ball and tapered roller bearings sized for heavy radial and thrust load capacity.

Circle 588 on Readers' Service Card

Royal Master Precision Centerless Grinder

Royal Master Grinders, Inc., Riverdale, N. J., has added to its line a high-precision, moderately priced centerless grinder with a permanently mounted crush dresser designed for through feed, plunge feed, and infeed. This Model CG-12 machine is 24 by 48 inches, including coolant tank. It grinds multiple-diameter parts and intricately shaped profiles, and can grind a variety of materials such as tungsten carbide, stainless or carbon steel, glass or plastic to a 0.0002-inch or 6- to 8-micro-inch finish. Wood, nonferrous metals, fiber, hard rubber, and cork can also be ground.

Among its special characteristics are: high output accuracy and fast checking with both sides of the wheel accessible from the operating position, and coolant tank mounted on casters for mobility. Standard accessories are kept in stock. The massive heat-treated alloy spindle is equipped with ball bearings that are lubricated for life. Wheel dressers can be either manually or hydraulically operated. The mounted wheel is easily lifted by one man, and the regulating wheel spindle is mounted "between" ball bearings to prevent deflection.

Circle 589 on Readers' Service Card

Regent Duplicator Tables

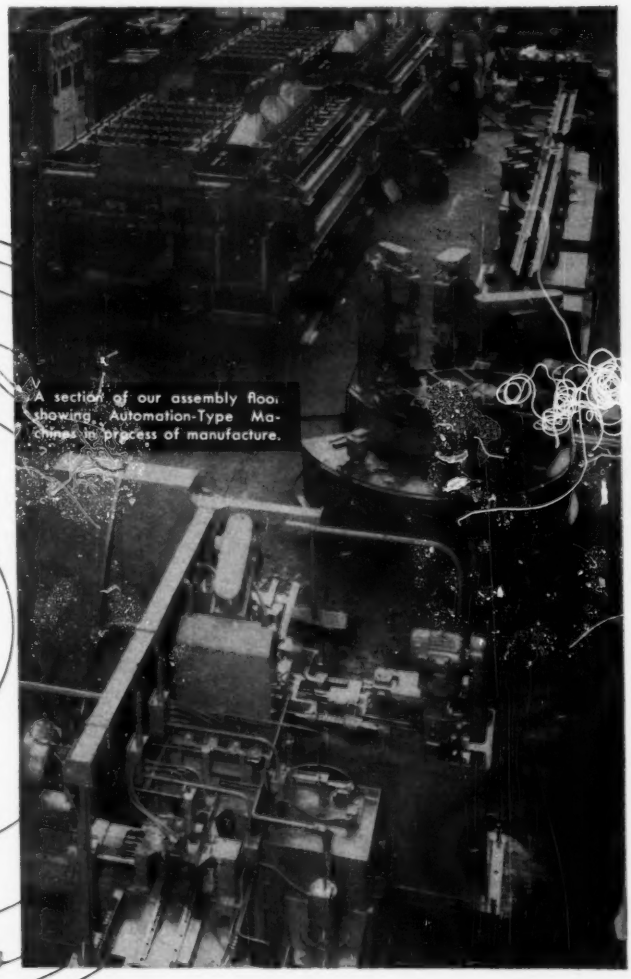
The James L. Howard Co., Hartford, Conn., has announced design improvements in its line of two- and three-dimensional duplicator tables, and that J. M. Kalins & Co., Bridgeport, Conn., will continue to distribute this line of equipment. The duplicator's ball-bearing raceways have been redesigned for greater rigidity and smoother operation. The overarm has also undergone changes that assure greater rigidity.

The Regent line features the R-200 two-dimensional fluid-motion duplicator for contour-profiling on any vertical miller and the R-300 for fast, accurate two- and three-dimensional duplicating and profiling of complex machined parts on Bridgeport millers only.

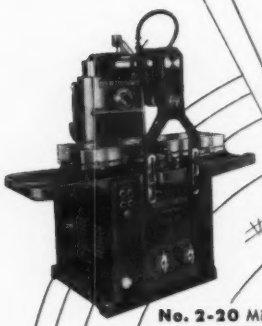
Circle 590 on Readers' Service Card

The Know-How Dimension

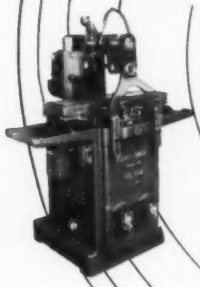
in Milling Machines..Special Machinery..Automation Equipment



A section of our assembly floor showing Automation-Type Machines in process of manufacture.

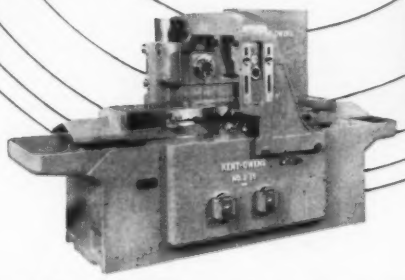


No. 2-20 Miller..20″ table travel . . 42″ x 12″ table . . full automatic hydraulic feed.



No. 1-14 Miller..14″ table travel . . 32″ x 9″ table . . hydraulic table feed . . full automatic cycle.

No. 3-36 Miller..36″ table travel . . 64″ x 16″ table . . full automatic hydraulic feed.



. . makes the difference in cutting costs . . increasing production

Know-How, born of years of experience, abetted by sound and imaginative design and quality manufacturing standards . . . is the reason why many of our customers, representing a wide and diversified coverage of industry, come back to us again and again for *answers* to their production problems.

When you are considering procurement of machinery for your milling needs . . . or seeking the solution to other production problems . . . you may wish to consider a Kent-Owens Milling Machine or a Special Machine designed for a distinctive and individual application. Contract Machine Building (customer designed equipment) is another of our specialties.

Write or call . . . Kent-Owens will be pleased to quote your requirements. Kent-Owens Machine Company, Toledo 10, Ohio.

KENT-OWENS *Designers and Builders of Milling Machines and Special Machinery*

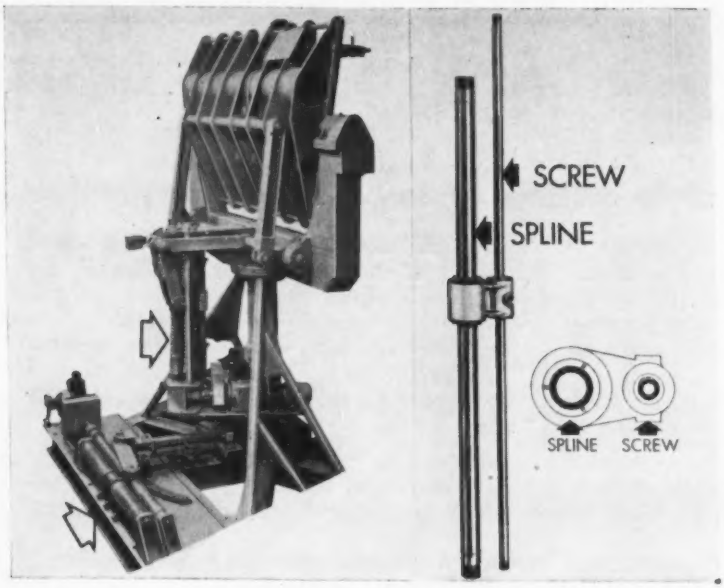
For more data, circle this page number on Readers' Service Card.

Analysis Chart for Roundness-Measuring Machine

TALYROND
ROUNDNESS
REPORT
Engis Analytical Metrology
Service to Industry
Polar Graph Analysis
Prepared for
Part
Date
1/10 inch on the graph represents
Comments
This polar graph made from your work, was prepared on a Talyrond Roundness Measuring Machine in our Chicago Test Facility.
The circle pattern on the cover helps to interpret the graph. The chart and cover have been so mounted together that one of the circles is "best fitting" to the graph. If you wish, you can separate and arrange differently to give more emphasis to the out-of-round characteristics critical for your job.
On the Talyrond, it is not necessary that the work be accurately centered in order to show true deviations from roundness. As the illustration shows, a part even appearing 0.5 inch off center on the chart shows an eccentric but correct graph.
The Talyrond provides an unfiltered (true) or a filtered graph of your part's circumference. Comparison of a typical example is shown in the three pictures below. Filters are a great help in clearly analyzing specific out-of-round conditions—either major lobing or closely spaced irregularities approaching surface roughness.
N
A
B
ENGIS EQUIPMENT COMPANY

Chart developed by Engis Equipment Co. for analysis of data produced on Talyrond roundness-measuring machine

(Left) Precision radar testing equipment using new ball-screw and ball-spline assembly shown at right. (Right) Ball screw and ball spline assembled with aluminum housing designed to tie two members together



As a special service to industry, and especially to users of the Talyrond roundness-measuring machine, the Engis Equipment Co., Chicago, Ill., has developed the Talyrond analysis report form, or chart, illustrated. The results obtained in checking out-of-round characteristics of gages and precision components of circular cross section on the Talyrond machine can be recorded and analyzed on this chart. The Talyrond machine's rotating spindle, true to 0.000001 inch, has weightless contact with the work, and performance is unaffected by size, balance, or shape of the work-piece. The instrument is self-checking and its accuracy can be verified.

The report chart designed by Engis is based upon an inkless graph with straight coordinate polar recording at magnifications up to 20,000×. This polar graph is part of the analytical metrology report and can be so placed with it that roundness, regardless of centering, is quickly established.

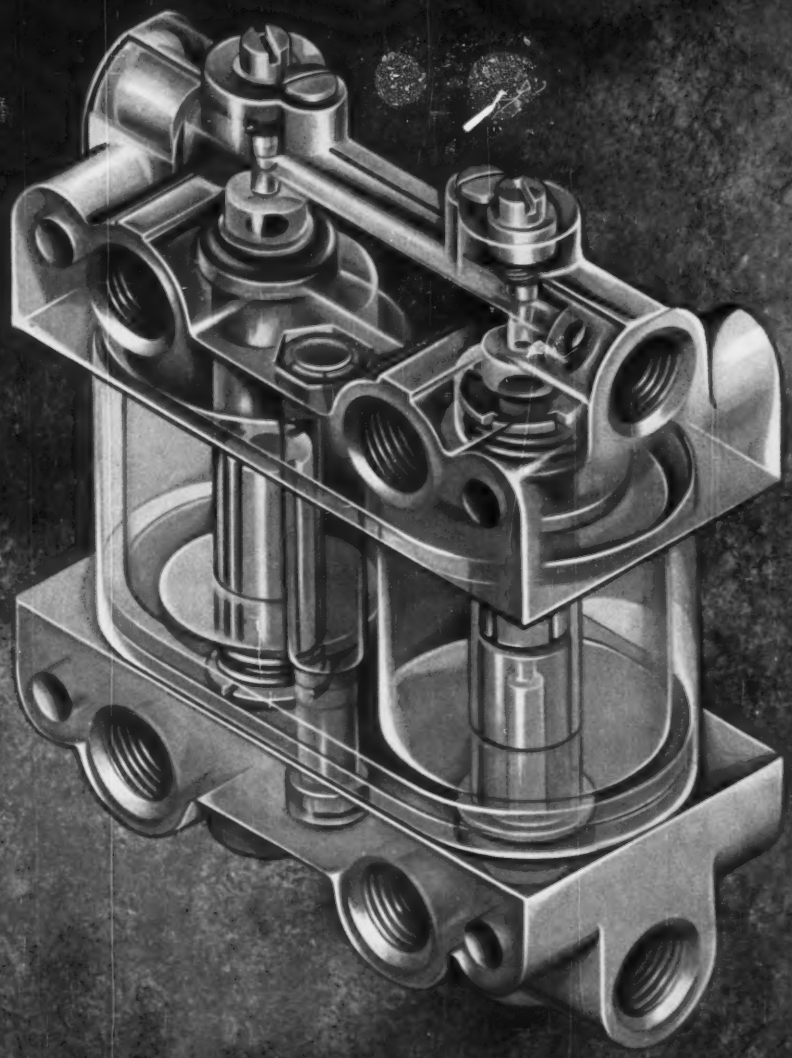
Talyrond roundness analyses are now available from leading metrology laboratories from coast to coast. The Engis Equipment Co. also maintains a test and development facility in Chicago.

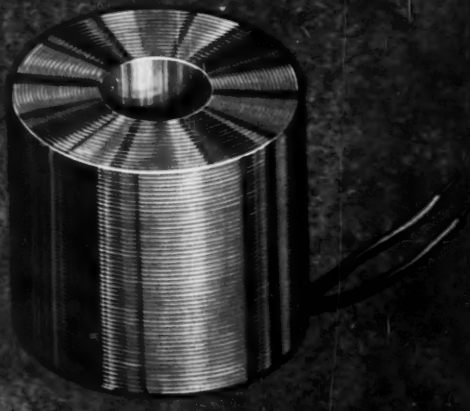
Circle 591 on Readers' Service Card

High-Precision Ball Screw

The use of a ball spline in conjunction with a ball screw has been successful in achieving unprecedented rigidity and performance in a high-precision actuating mechanism without impairing the efficiency of the ball screw, according to an announcement by Beaver Precision Products, Inc., Clawson, Mich. Conditions indicated that a 1 1/4-inch pitch diameter, 48-inch long ball screw was needed to meet the exacting requirements. Deflection, however, which would result from side thrust and torque would cause impairment of control in a conventionally mounted screw of this size. The problem was met and deflection was counteracted by using a rigid, 2 1/2-inch diameter ball spline with the ball screw, as shown in the view to the right in the illustration. The nuts of both

(Continued on page 186)





Compact 4-way

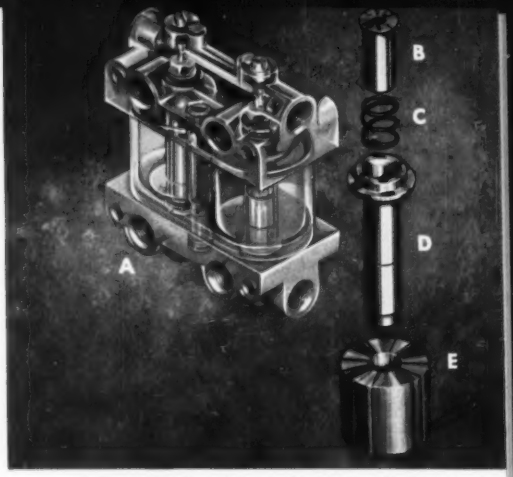
SKINNER

Solenoid Valves

assure precise cylinder control

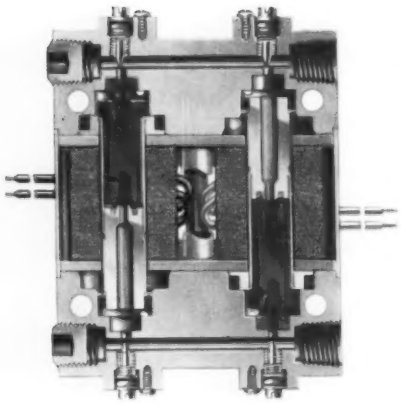
Here's how accurate, dependable operation is built into SKINNER 4-way solenoid valves

- **Precise flow control**—by adjustable metering
- **Compact, direct acting**—two 3-way valves in one housing
- **Durable and corrosion resistant**—stainless steel internal parts
- **Leakproof, bubbletight sealing**—soft, synthetic inserts
- **Positive operation mounted in any position**—spring-loaded plungers
- **Underwriters approved**—wide selection of coils, voltages and frequencies
- **Wired from front or rear**—housing easily reversed
- **Adaptable to many uses**—optional porting arrangements



A. Transparent view of 4-way solenoid valve B. Plunger
C. Plunger return spring D. Sleeve E. Coil

SKINNER four-way solenoid valves available in three basic types



The Skinner V9 solenoid valve is two 3-way valves in one compact housing. Both valves may be independently controlled and metered to provide accurate, dependable control of single- or double-acting cylinders, or larger pilot-operated valves.

V9 types are available without adjustable flow and with metering at both exhaust ports, both inlet ports or full metering of all ports.

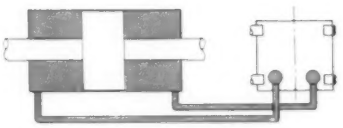
• • •

For complete information, contact a Skinner Distributor listed in the Yellow Pages or write us at the address below.

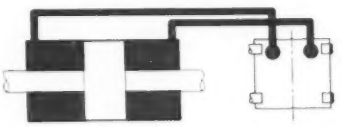
V9 SERIES SPECIFICATIONS

Media—air, hydraulic oils, inert gases
Orifice Diameter—$\frac{3}{64}$", $\frac{1}{16}$", $\frac{3}{32}$", $\frac{1}{8}$"
Pipe Size—$\frac{1}{4}$" NPTF
Maximum Operating Pressure Differential—0 to 150 PSI (up to 225 PSI also available)
Temperature Range—minus 40°F. to plus 180°F.
C_V Factor—$\frac{3}{64}$" .052, $\frac{1}{16}$" .095, $\frac{3}{32}$" .156, $\frac{1}{8}$" .214
Mounting—$\frac{1}{4}$" through-bolt holes.

Normally closed—normally closed V933 valves with a neutral position. Generally applied on double-acting cylinders where the piston is in a neutral position without pressure when both coils are de-energized. This permits manual shifting of the piston without operating the valve.



Normally open—normally open V955 valves with a neutral position. Generally applied on double-acting cylinders where both sides of the piston are to be open to pressure when both coils are de-energized. Under certain conditions, the first operating stroke of double-acting cylinders will be smoother with this valve in use.



Normally closed—normally open V935 valves with no neutral position. Generally applied on double-acting cylinders where the piston is to be in retracted or extended position with pressure when both coils are de-energized. Wiring is simple—both coils are operated simultaneously and can be controlled by one single-pole, single-throw switch.

When you specify solenoid valves, specify Skinner. Skinner solenoid valves are distributed nationally.

SKINNER ELECTRIC VALVES ®
THE CREST OF QUALITY

SKINNER ELECTRIC VALVES

SKINNER ELECTRIC VALVE DIVISION
SKINNER PRECISION INDUSTRIES, INC. • NEW BRITAIN, CONNECTICUT, U.S.A.

PRINTED IN U.S.A.

NEW CATALOGUES

Isabel Shamlian
Charles O. Herb, Jr.

Catalogues bring details of new products to prospective buyers in clear, concise form. Yours for the asking . . . use postcard between pp. 181 & 183

Finishing Mill

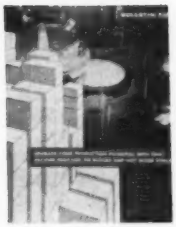
Southwestern Engineering Co., Vibro-Equipment Division, Los Angeles, Calif. Brochure providing descriptive details on the Sweco "Vibro-Energy" finishing mill, which is said to combine the most desirable features of vibratory, barrel, and rotary motion.

Circle **Item 501** on Inquiry Card

Dial Indicator

Southwestern Industries, Inc., Los Angeles, Calif. Catalogue giving details on the company's Trav-A-Dial indicator, which provides a continuous indication of carriage, slide, or tool position in relation to the work-piece within 0.001 inch.

Circle **Item 502** on Inquiry Card



Die-Blocks and Hot-Work Steels

A. Finkl & Sons Co., Chicago, Ill. Bulletin 200 featuring data on the company's vacuum-degassed die-blocks and hot-work steels. Information pertaining to ordering the die-block, shanking, sinking, setting up, operation, and resinking is presented.

Circle **Item 503** on Inquiry Card

Heat-Processing Furnaces

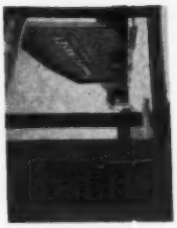
General Electric Co., Schenectady, N. Y. Bulletin GER-1751 explaining how to prepare an economic study on heat-processing furnaces. Featured are sections on where to obtain data, how to make the study, three typical examples, table, etc.

Circle **Item 504** on Inquiry Card

Sharpening Device

Harig Mfg. Corporation, Chicago, Ill. Bulletin containing data on the firm's Air-Flo fixture for sharpening end mills, routers, staggers, plain mills, angle cutters, etc. It is said to eliminate all metal-to-metal contact with a film of air.

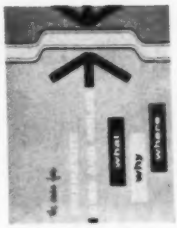
Circle **Item 505** on Inquiry Card



Research Program

Warner & Swasey Co., Cleveland, Ohio. Brochure on the company's research and development program. Departments in the W&S research center include machine design, systems design, metallurgical laboratories, a prototype shop, etc.

Circle **Item 506** on Inquiry Card



Dies and Molds

Meehanite Metal Corporation, New Rochelle, N. Y. Bulletin No. 50 presenting information on Meehanite dies and molds. Self-lubricating properties, castability, machinability, hardenability, dimensional stability, strength, etc., are discussed.

Circle **Item 507** on Inquiry Card

Contact Wheels and Rolls

Carborundum Company, Niagara Falls, N. Y. Folder No. A1566 presenting a discussion of the engineering principles behind the operation of contact wheels and rolls. Theory, selection, ordering, and use of contact wheels are fully covered.

Circle **Item 508** on Inquiry Card

Tool-Holders

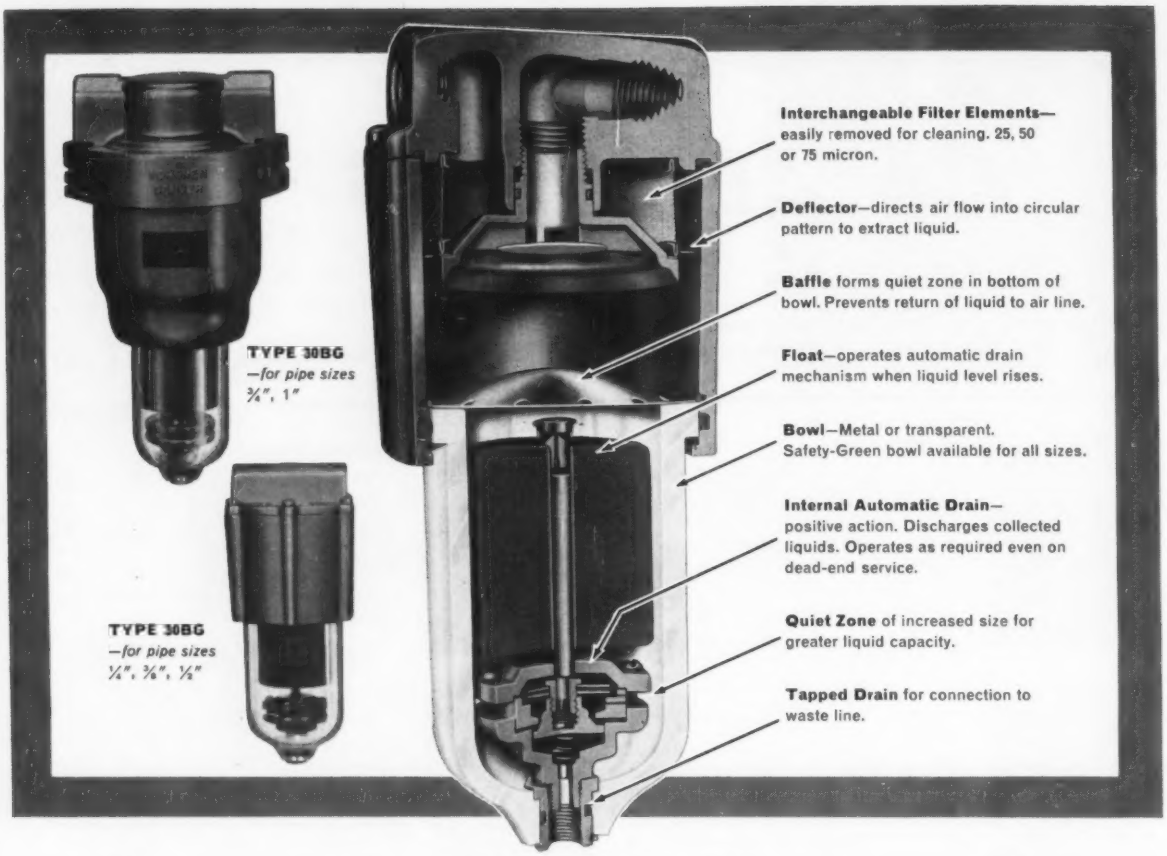
Erickson Tool Co., Solon, Ohio. Catalogue L (Section B) describing the firm's full-floating tool-holders and flanged adjustable holders. The full-floating holders grip reamers firmly, yet compensate for both parallel and angular misalignment.

Circle **Item 509** on Inquiry Card

Instrument Components

Pic Design Corporation, East Rockaway, N. Y. Master Catalogue 21 presenting the firm's precision instrument components. Among the items featured are gears, measuring wires, bronze bearings, couplings, speed reducers, and retainer rings.

Circle **Item 510** on Inquiry Card


TYPE 30BG
—for pipe sizes
¾", 1"
TYPE 30BG
—for pipe sizes
¼", ⅜", ½"
Interchangeable Filter Elements—easily removed for cleaning. 25, 50 or 75 micron.
Deflector—directs air flow into circular pattern to extract liquid.
Baffle forms quiet zone in bottom of bowl. Prevents return of liquid to air line.
Float—operates automatic drain mechanism when liquid level rises.
Bowl—Metal or transparent. Safety-Green bowl available for all sizes.
Internal Automatic Drain—positive action. Discharges collected liquids. Operates as required even on dead-end service.
Quiet Zone of increased size for greater liquid capacity.
Tapped Drain for connection to waste line.

Norgren Automatic-Drain Compressed-Air-Line Filters provide FULL-TIME protection

The purpose of a compressed-air-line filter is to remove liquids and solids from the air-stream so that they cannot clog, corrode or damage air-powered equipment. Your equipment needs this protection *full-time.*

Manual drain filters are often neglected . . . are not drained as often as they should be. When excess liquid collects in the bowl these filters no longer do the job. Liquid in the air-stream passes right on through to your air tools, cylinders and other air-operated equipment.

This cannot happen with Norgren Automatic-Drain Filters. They empty themselves as often as required . . . never get too full. Operation is determined entirely by the need for draining; and not, as with some makes, by changes in air pressure. Although an automatic-drain filter costs more than a manual drain filter, Norgren Automatic-Drain filters protect your air-powered equipment *full-time* day and night, year-in-year-out. They prevent costly wear and damage to your equipment and eliminate man-hour costs for manual draining.

Order Norgren Automatic-Drain Filters from your nearby Norgren Representative, listed in the telephone directory—or write factory for catalog.

FOUNDED IN 1925

C. A. NORGREN CO.

3419 SOUTH ELATI STREET, ENGLEWOOD, COLORADO

• Yours for the asking . . . use postcard between pp. 181 & 183

Gears

Perkins Machine & Gear Co., West Springfield, Mass. Folder featuring the company's helical, bevel, worm, face, and spur gears; sprockets; ratchets; worms; splined shafts; and clutches. A table showing size ranges of gears, etc., is included.

Circle **Item 511** on Inquiry Card

Optical Comparators

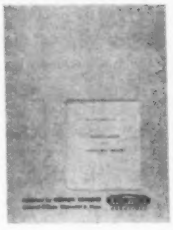
Nikon Inc., New York City. Brochure describing the company's Model II bench unit and Model III floor unit optical comparators. Lenses, mirrors, contrast filters, plain and fixed stages, surface illuminator, vise fixture, etc., are featured.

Circle **Item 517** on Inquiry Card

Vibration Signal Analyzer

Raydata Corporation, Columbus, Ohio. Bulletin covering the firm's Model 41 vibration signal analyzer, which operates on rechargeable battery-pack or standard line power, accepts a variety of pickups and tranducers, has modular construction, etc.

Circle **Item 512** on Inquiry Card



Pressure Blasting

Norton Co., Worcester, Mass. Report on pressure blasting with manufactured abrasives, describing the areas of applications and various media used. Emphasis is on the proper selection and use of aluminum-oxide and silicon-carbide abrasive.

Circle **Item 518** on Inquiry Card

Barrel-Plating Equipment

Udylite Corporation, Detroit, Mich. Booklet containing data on multiple-use barrel-plating equipment. Recommendations for barrel assemblies, horizontal barrel units, loading stands, storage and transfer units, and final rinse units are included.

Circle **Item 513** on Inquiry Card

Hard-Facing Alloys

Wall Colmonoy Corporation, Detroit, Mich. Manual No. 79 covering data on hard-facing alloys. Included are descriptions of the Sprayweld process, standard castings, Nicrobraz brazing filler metals for high-temperature service, and special alloys.

Circle **Item 519** on Inquiry Card

Air-Hydraulic Cylinder

Sheffer Corporation, Cincinnati, Ohio. Bulletin No. 561 covering a CLH stud-mount double-acting or spring-return clamp type heavy-duty air or hydraulic cylinder (250 psi air; 1500 psi hydraulic) for compact machine tool and automation applications.

Circle **Item 514** on Inquiry Card

Lathe

Bullard Co., Bridgeport, Conn. Catalogue giving information on the company's Type "M" Mult-Au-Matic lathe, available in six-, eight-, and twelve-spindle models. General construction, features, and complete specifications are included.

Circle **Item 520** on Inquiry Card

Gages

Regal Division, Beloit Tool Corporation, Beloit, Wis. Bulletin 59-5 providing information on the firm's line of gages. Thread plug and thread ring, cylindrical steel plug, and tungsten-carbide plug gages are described, plus master setting discs.

Circle **Item 515** on Inquiry Card

Small Tools

Armstrong Bros. Tool Co., Chicago, Ill. Catalogue No. 700 presenting the complete Armstrong line of toolholders, setup and hold-down tools, tool bits, machine-shop specialties, wrenches, socket wrenches, miscellaneous hand tools, pipe tools, etc.

Circle **Item 521** on Inquiry Card

Casting Processes

Lebanon Steel Foundry, Lebanon, Pa. Brochure describing the techniques and facilities of the company's Specialty Foundry Division. Included are details on the shell-molding process, Ceramicast process, and combined ceramic-mold and lost-wax techniques.

Circle **Item 516** on Inquiry Card

Drawing Lubricant

Magnus Chemical Co., Garwood, N. J. Catalogue on Magnus DO-29, a drawing lubricant that combines the tool and die life expected from chlorinated oils with the aqueous cleaning facility of water-soluble oil. A recommendation chart is included.

Circle **Item 522** on Inquiry Card

• Yours for the asking . . . use postcard between pp. 181 & 183

Material Handling

Globe Hoist Co., Philadelphia, Pa. Manual on material handling, featuring fifty-nine ways to lift, load, position, and machine-feed more efficiently. Applications cover heavy manufacturing, mining, paper mills, institutions, aircraft assembly, etc.

Circle **Item 523** on Inquiry Card

Spline Gage

Vinco Corporation, Detroit, Mich. Bulletin SP615 covering uses and features of the Vinco Splinedicator, a composite indicator spline gage available in plug and ring models. It can be readily incorporated into semiautomatic gaging equipment.

Circle **Item 529** on Inquiry Card

Driving Centers

Power Grip, Inc., Rockfall, Conn. Catalogue 50361 describing a driving center that is said to reduce production time and cost on work held between centers. It grips the end face of the work without clamps, chucks, or other bulky devices.

Circle **Item 524** on Inquiry Card

Abrasive-Cloth Wheel

Merit Products, Inc., Los Angeles, Calif. Catalogue (Form No. FD-30) providing descriptive details on the firm's Type B Flex-Drum, an abrasive-cloth wheel for sanding, polishing, and satin-finishing flat, contoured, or complex surfaces.

Circle **Item 530** on Inquiry Card

Nose-Grinding Fixtures

Eldorado Tool & Mfg. Corporation, Milford, Conn. Brochure (Form No. 19) on a nose-grinding fixture which incorporates a rocker motion for accurate and economical sharpening of gun drills. It may be used with any bench or pedestal grinder.

Circle **Item 525** on Inquiry Card

Polishing Rolls

Carborundum Company, Niagara Falls, N. Y. Folder on the firm's Flexbac polishing rolls for lapping crankshafts and bearings, which cut abrasive costs while maintaining the micro-inch finishes required for these high-speed bearing surfaces.

Circle **Item 531** on Inquiry Card

Sleeve Bearings

Link-Belt Co., Chicago, Ill. Folder 2823 announcing two types of self-aligning and self-lubricating sleeve bearings in flanged- and pillow-block types that solve application problems of temperatures up to 1000 degrees F., corrosive conditions, etc.

Circle **Item 526** on Inquiry Card

Honing Equipment

Superior Hone Corporation, Erwin, Tenn. Brochure presenting details on honing machines, drill-press adapters, mandrels, and stones. Selection of abrasive stones, recommended honing speeds, etc., are covered. A price list is included.

Circle **Item 532** on Inquiry Card

Tooling Plate

Aluminum Company of America, Pittsburgh, Pa. Pamphlet giving a description of the company's complete line of aluminum tooling plate, designed to meet all machining specifications. Three grades—Alcoa Types 100, 200, and 300—are covered.

Circle **Item 527** on Inquiry Card

Manufacturing Facilities

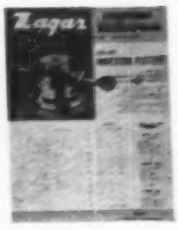
Pioneer Tool & Engineering Co., Chicago, Ill. Booklet on the firm's facilities and equipment for research, development, engineering and tooling. Pioneer is concerned with components for stable platforms, analog and digital computers, etc.

Circle **Item 533** on Inquiry Card

Punches and Dies

Oberg Carbide Punch & Die, Inc., Freeport, Pa. Catalogue sheet giving information on the company's carbide punches and dies. Specification tables for solid carbide punches and die bushings are included, along with a temporary price list.

Circle **Item 528** on Inquiry Card



Collet Fixtures

Zagar, Inc., Cleveland, Ohio. Bulletin providing descriptions of all models of the company's collets and collet fixtures. Featured are a collet lathe chuck, air-operated holding fixture, and turntable fixture. Specifications are included.

Circle **Item 534** on Inquiry Card

Tool Steel Topics

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Auto fenders trimmed with dies made from water-hardening tool steel

These photographs, taken at Mardigian Corporation, Warren, Mich., show the use of Bethlehem carbon water-hardening tool steel in trim dies for automobile front fenders. The dies, hardened to Rockwell C 62-64, trim 20-gage cold-rolled sheet steel. In the picture above, 15 sections of the tool steel, bolted into the casting, are ready for "Kellering." The companion picture was taken after the tool steel sections were machined to contour and heat-treated, making a completed form-and-trim die.

Engineers at the Mardigian plant reported fine results with Bethlehem carbon water-hardening tool steel. They especially liked its excellent machinability and uniform response to heat-treatment, plus the fact that modification could be easily accomplished by welding.

Due to their carefully controlled hardenability, Bethlehem carbon water-hardening grades deliver long service in applications calling for high shock-resistance. They have good resistance to wear, and plenty of toughness to resist the effects of cold battering.

Your Bethlehem tool steel distributor has a wide range of carbon water-hardening steels in stock. He will be pleased to meet your needs. Get in touch with him today.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

Avoid Early Failure of Cutting Tools by Removing the "Feather" Edges

When a grinding wheel crosses a tool edge, a small burr or "feather" remains on the edge, no matter how carefully or properly the grinding operation may have been carried out. If the tool is used with the feather-edge, it is equivalent to using a tool having a dulled cutting edge. Obviously, production from such a tool will not be as high as from a similar tool with sharp edges. Many machinists, recognizing this, carry a hand stone which they use in removing the feather from the cutting edges. However, the most practical and positive method of removing the feather from the edges of ground tools is by fiber brushing on a rotary wheel.

By removing the feather-edge before a tool is placed in service, the user is assured of increased production because the edges of the tool do not dull as rapidly.

• Yours for the asking . . . use postcard between pp. 181 & 183

Tubing

Joseph T. Ryerson & Son, Inc., Chicago, Ill. Bulletin 12-10 (revised) discussing characteristics, size range, and relative cost of carbon- and alloy-steel tubing. Stainless-steel, aluminum, and industrial plastic tubing are also covered.

Circle **Item 535** on Inquiry Card

Brazing of Stainless Steel

Wall Colmonoy Corporation, Stainless Processing Division, Detroit, Mich. Catalogue describing the firm's facilities and skills for brazing and heat-treating stainless steel and special alloys. Illustrations of parts brazed with Nicrobraz are featured.

Circle **Item 541** on Inquiry Card

Rod Ends

Split Ballbearing division of MPB, Inc., Lebanon, N. H. Catalogue 101 describing Alinabal large-size rod ends, control rod assemblies, and high-angle rod ends with studs. Advantages, such as wide selection of ball material, are discussed.

Circle **Item 536** on Inquiry Card

Numerical-Positioning Controls

Rheem Electronics, a division of Rheem Mfg. Co., Los Angeles, Calif. Bulletin presenting numerical-positioning controls. Tape, tape preparation unit, tape reader, sequence control, bi-directional summing register, power supplies, etc., are covered.

Circle **Item 542** on Inquiry Card

Air Motors and Vacuum Pumps

Gast Mfg. Corporation, Benton Harbor, Mich. Catalogue 660 containing data on a line of rotary air motors, air compressors, and vacuum pumps for original-equipment manufacturing or plant use. Air-motor sizes 1/20 to 7 hp are available.

Circle **Item 537** on Inquiry Card

Press

Havir Mfg. Co., St. Paul, Minn. Catalogue (Form No. 461) covering the largest Havir Press-Rite ever built—a 125-ton open-back inclinable model. Such features as large die area and extended shut height make it applicable to many jobs.

Circle **Item 543** on Inquiry Card

Tool-Holder

Koning Machine & Tool Co., Holland, Mich. Folder giving a description of the Koning tool-holder, which is machined to fit the customer's lathe, is designed for maximum rigidity, permits fast stock removal, increases tool life, etc.

Circle **Item 538** on Inquiry Card

Operation Monitors

Raydata Corporation, Columbus, Ohio. Catalogue featuring details on the firm's Series 18 operation monitors, which provide monitoring and control of machine performance and process adjustment. A discussion of the "Spectrum Analysis" technique is given.

Circle **Item 544** on Inquiry Card

Dip Brazing

Precision Dipbraze, Inc., North Hollywood, Calif. Brochure covering the basic advantages of using the dipbraze method for joining numerous aluminum segments into a complex, intricate, or elaborate assembly; data on material selection; etc.

Circle **Item 539** on Inquiry Card

Taps

Regal Division, Beloit Tool Corporation, Beloit, Wis. Catalogue 60-1 featuring information on the firm's line of taps. Ground-thread high-speed-steel, spiral-point, pipe, nut, pulley, spiral-fluted, and extension taps are fully covered.

Circle **Item 545** on Inquiry Card

Machine Mounts

Clark-Cutler-McDermott Co., Franklin, Mass. Catalogue 4011 presenting the company's complete line of machinery mounts: Wedgmounts, Jacmounts, and Air-Loc mounting pads. Each type is illustrated and available sizes and capacities are listed.

Circle **Item 540** on Inquiry Card

Drop-Hammer

Chambersburg Engineering Co., Chambersburg Pa. Bulletin No. 105-L-1 on the Ceco-Drop piston-lift gravity drop-hammer. Described are the die-setting control, instant-acting non-slip rod clamp, replaceable nylon tips for the knock-off dogs, etc.

Circle **Item 546** on Inquiry Card

catalogues . . . . bulletins . . . . manuals

• Yours for the asking . . . use postcard on following page

UNIT PARTS

Boston Gear's catalog #57 gives complete listings on their **RATIO MOTORS** from 1/6 to 15 HP drives—Furnished ready to install from Boston Gears large stock. To obtain circle 43

For catalog on C. A. Norgren's Automatic-Drain Compressed-Air Line **FILTERS.** Circle 174

Eisler Engineering Company's **CAMS** of all types and sizes made to your specifications. To obtain their catalog—circle 207C

Eonic offers catalog on their line of all types of experimental and production **PRECISION CAMS** and **CAMSHAFTS.** To obtain circle 209C

MACHINE TOOLS

For descriptive literature on Ex-cell-os' **AUTOMATIC FORM** and **GROOVE GRINDER.** Circle 19

Monarch Mch. Co. offers new booklet on their 10" Model **EE LATHE** featuring ability to super-precision turn small parts. To obtain circle 20

To obtain Ex-cell-os' bulletin 436014 featuring their **LECTRA-FORM MACHINES**—removes metal through high current low voltage electrical spark discharge. Circle 23

Steelweld Catalog lists complete line of their **SHEARS** available in all sizes for cutting steel plate to thickness of 2". To obtain circle 30

Verson offers 24 page catalog describing representative models of their entire line of mechanical and hydraulic **PRESSES** and press brakes. To obtain circle 38-39

To obtain Seneca Falls Machine bulletin featuring their model "CS" **AUTOMATIC CENTERING MACHINE.** Circle 54

Two informative handbooks "Faster **GEAR** Production" and "Know Your **SHAPER CUTTERS**" available from Illinois Tool Works. Circle 59

New Britain Mch. offers catalog on their versatile **BAR MACHINES.** Tooling combinations are practically limitless. To obtain circle 61

New Britain Mch. offers catalog featuring their **COPYING LATHE** plus their line of special tooling attachments for complicated jobs. To obtain circle .. 62

Kearney & Trecker offers bulletin on their all new 5 HP Knee type **MILLING MACHINE.** To obtain circle 67

Niagara Mch. Co. offers bulletins on their—**DIES,** and their 15-, 30-, 60-ton mechanical; 90- through 1000-ton mechanical; 200- through 1000-ton Hydraulic **PRESS BRAKES.** For correct order numbers for each of these bulletins. See page 69

Blanchard Machines booklet. The Art of Blanchard **SURFACE GRINDING**—ground finishes to 2-Micromes-Flatness to 1-light band. To obtain circle 74

Le Blond Mch. offers descriptive bulletin on their **HEAVY DUTY LATHE**—featuring The General Electric Mark Century Control unit. To obtain circle 154-155

Goss & De Leeuw offers illustrated literature on their line of automatic **CHUCKING** machines. To obtain circle .. 187

TY-SA-MAN Machine Company's bulletin on their **ABRASIVE SAW**—rotates metal. Cuts 16 to 20 I PMs on hard alloys. To obtain circle 205

New Sheldon Mch. 3-R **TURRET LATHE** for 8-station production machining. For bulletin giving complete specifications and tooling data. Circle 206

For bulletin describing Pines Engineering Grieder **CUT OFF MACHINES** designed to produce 4500 to 6500 cut-offs per hour. Circle 213

U S I Clearing offers catalog on their **HYDRAULIC PRESSES** for compacting, stamping or drawing. To obtain circle ..... Back Cover

Brochure descrbes W. F. & John Barnes' **MACHINE TOOL** building facilities. Individual bulletins also available on wide variety of drilling, boring and tapping machines. Circle 846

For the facts on how improved machines based on Sundstrand evaluation can reduce your **TURNING** costs. Circle 849

Machines to improve your **THREADING** operations are described in a new Sundstrand bulletin. To obtain circle .. 851

CUTTING TOOLS

Landis Mch. bulletin gives complete information on the various sizes of their ALT **TAPS** for threading all diameters from 1¼ to 13¼. To obtain circle 2-3

To obtain detailed literature on the Star Cutter Company's line of **GUN DRILLING TOOLS.** Circle 57

Continued on page 180

Continued from page 179

MISCELLANEOUS

New Armstrong general catalog showing their complete line plus approximately 330 new **TOOLS** never included in previous Armstrong catalogs. To obtain circle 12

Ex-Cell-O offers bulletin on their line of **BUILDING BLOCKS**—can be used to build simple one way precision machines or huge multistation transfer machines. To obtain circle 27

Inland Steel Company offers booklet "Properties of Ledloy **STEELS.** To obtain circle 37

Allen-Bradley offers bulletin on their new **TERMINAL BLOCKS.** With these new snap-on Terminal Blocks, you can have up to 29 blocks per foot. To obtain bulletin circle 42

Textile Machine Works booklet. "Facilities File Folder" describes their **SUBCONTRACTING** facilities. To obtain circle 66

Gulf Oil Corporation's bulletin on their **COOLANT**—"Gulfcut" shows many cost cutting benefits. To obtain circle 146-147

To obtain catalog featuring Universal Engineering's **INDEX PLUNGERS** plus some of their other production tools Circle 160

Federal Products offers brochure on their new **DIAL INDICATOR**—new design provides repetitive accuracy to within five millionths of an inch. To obtain circle 167

Engineering data on Zagar's **DRILL HEADS** for drilling, reaming and tapping. Circle 203A

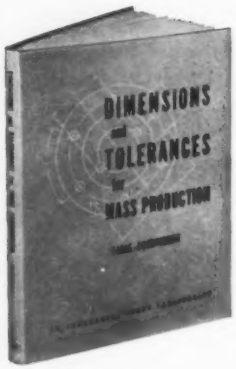
To obtain Houston Grinding Company's catalog featuring their **LIVE CENTERS** made of finest alloy steel. Circle .. 208

For literature and technical data on the Winslow Product Corporation's **DRILL POINTER**—completely automatic, produces helical, split point etc. Circle 212

3 USEFUL BOOKS FOR PRODUCTION ENGINEERS

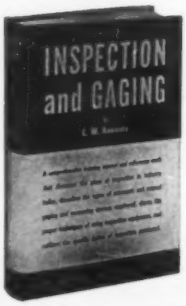
ENGINEERED WORK MEASUREMENT by Delmar W. Karger and Franklin H. Bayha.
An up-to-date, complete text on Methods-Time Measurement, the internationally recognized predetermined time systems, this book covers MTM thoroughly, expertly. Fourteen chapters describe the fundamentals of MTM, such as Reach, Move, Grasp, Release. Every term is clearly defined and illustrated. Special MTM mathematics, standards and applications, as well as organization and development of MTM training courses are covered. *Engineered Work Measurement* will help you in providing standard data and time formulas, controlling labor costs, evaluating existing systems, improving methods and estimating production costs.

630 pages, 130 illustrations. $12.00



DIMENSIONS AND TOLERANCES FOR MASS PRODUCTION by Earle Buckingham.
An analysis of the many problems of dimensioning with tolerances for mass production, showing their effect on tool design, gage design, production and inspection, and suggesting improved methods and practices to solve these problems. Worked-out examples show how improved methods and practices of dimensioning with tolerances can be the key to better production at lower costs. This book will help you develop sounder, more practical procedures, not only in the design stage, but also in manufacturing, inspection and assembly.

164 pages, 179 illustrations. $8.00



INSPECTION AND GAGING by Clifford W. Kennedy.
This book covers the many phases of inspection work: their application to present-day manufacturing operations; the variety of measuring devices and gages which are available; their specific functions and the specialized techniques of using them; the methods and duties of the different type of inspectors; the new developments in and applications of electric and electronic gaging and sorting, automatic gage control of machines, air and air-electric gaging, optical comparators, alignment telescopes and auto-collimators.

522 pages, 345 illustrations. $9.00

THE INDUSTRIAL PRESS, 93 WORTH ST., NEW YORK 13, N. Y.

Please send me the book(s) I have checked below.

☐ 1. Engineered Work Measurement
☐ 2. Dimensions and Tolerances For Mass Production
☐ 3. Inspection and Gaging

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☐ Bill Company
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Orders from outside U.S.—except Canada—add 50¢ for postage and handling.

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0217

feel free to use cards below . . . to obtain free literature on products advertised or described in this issue

1. Circle page numbers of advertisements—if no page number appears on ad, refer to advertisers' index.
2. Circle item numbers of new equipment, catalog descriptions.
3. Mail . . . we'll do the rest.

For Advertisements—Circle Page Numbers

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information center

Reverse side of this card gives instructions on how to use postcards below to obtain new catalogues, data on new equipment described, and products advertised in this issue.

This card expires November 1, 1961

FIRST CLASS
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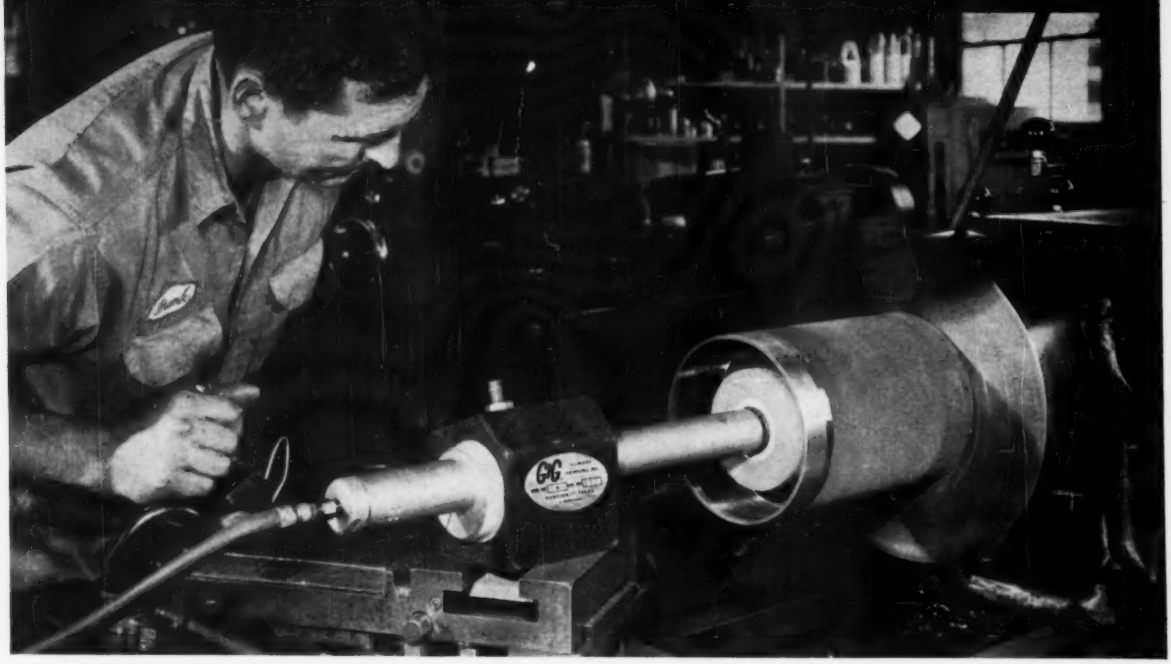
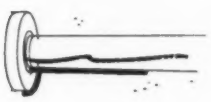
You've never seen a tool post grinder so compact . . . so easy to use! The motor's inside the quill!

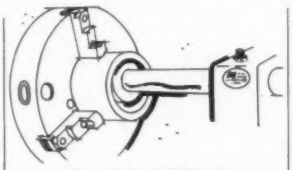


The minute you see the Gilmore T-P Tool Post Grinder you'll wonder why no one ever thought of it before! It does away with the need for a bulky electric motor and dangerous belts. Gives complete visibility for internal grinding. Uses the same quill for both internal and external grinding. Has a unique adjustable eccentric so you can move it from one size lathe to another without fuss or bother! Just one bolt adjustment secures quill and eccentric in support block and also mounts support block on lathe compound.

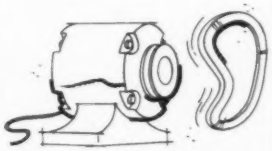
What makes all this possible? One thing is a *one-horsepower* adjustable speed air motor, enclosed *in the quill*. It's the most compact tool post grinder motor, and is completely out of the way. Lets you adjust a taper attachment, for instance, without getting a belly full of motor!



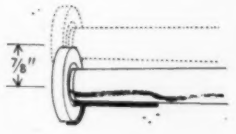
Just one quill handles both inside and outside grinding!



Gives full visibility for inside grinding!



No bulky electric motor! And no dangerous drive belt or pulleys!



Unique adjustable eccentric gives full 7/8" vertical quill adjustment!

MONEY BACK GUARANTEE!
Try the Gilmore T-P Tool Post Grinder in your own shop for 30 days—If you're not completely sold on it, return it and we'll refund your money!

Manufactured by

GILMORE INDUSTRIAL GRINDERS INC.

Developers of the GG Portable Grinder
6523 Eppes St. Houston 17, Texas

GILMORE INDUSTRIAL GRINDERS, INC. · 6523 EPPES ST. · HOUSTON 17, TEXAS

☐ I am enclosing check for $680.00 (plus local sales taxes, where applicable) for the Gilmore T-P Tool Post Grinder with carrying case shipped prepaid. If I'm not satisfied after 30 days, I will return the unit and you will refund my money.

☐ Ship (subject to credit approval) on open account. P. O. # _____

☐ Please send more information.

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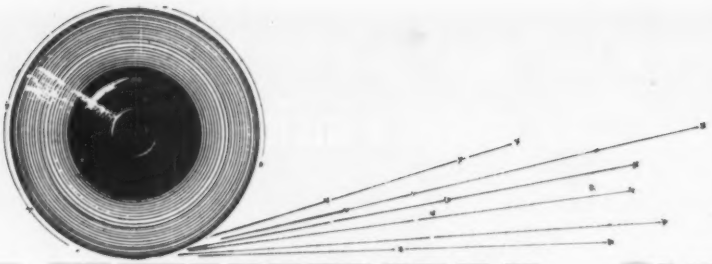
COMPANY _____

NAME OF USUAL MACHINE TOOL SUPPLIER _____

For more data, circle this page number on Readers' Service Card.



By E. S. Salichs

BETWEEN GRINDS

Distant Doings

Westinghouse and Aerojet will design the so-called Nerva engine for the Government, the first step in the actual manufacture of the nuclear moon rocket. Estimates of when the first Nerva engine might be flight-tested have ranged from 1965 to 1967. Nerva, incidentally, stands for "nuclear energy rocket vehicle application." This project will require brains and money, besides nerva.

A Car for Every Carp

The United States Navy, we read, is now permitting sportsmen to lower wrecked automobile bodies offshore, thereby attracting fish to artificial reefs. The big question is, Will fish now become Cadillac-conscious, or have they always been?

Homeward Bound and Wired for Sound

A pigeon-tracking system has been developed by American Electronic Laboratories, Inc., for the Office of Naval Research, whereby a pigeon is equipped with a transmitter which emits radio signals while the pigeon is homing-in to its roost. The idea behind this research is that if scientists understand their pigeons, they may be able to improve navigational systems for civilian and military use.

Chiseled and Fizzled

A college student unprepared to take a multiple-choice type test, later to be graded by an electronic machine, tried to beat the brain. His plan was to make small dots with his pencil in all the choice blanks, hoping that the dots would escape the instructor's eye but would still register with the machine. The machine, however, refused to grade the paper. The plan didn't work, but now the student will.

Bye, Bye, Bolts

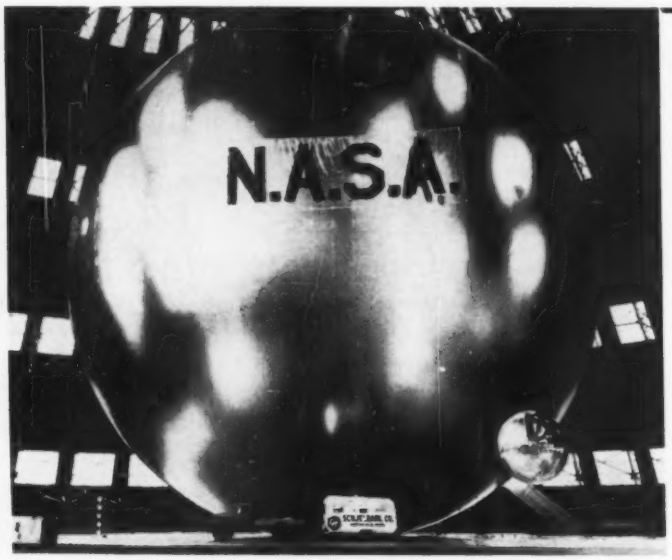
United States railroads are stepping up the installation of continuous welded rail, reducing the number of conventional bolted joints with their "clickety-clack" gaps between the rails. It seems welded rail reduces costs by about $1000 per mile each year, in addition to savings from freight damage, according to the Chemetron Corporation, which produces much of this welded rail. If you have depended on the rhythmic clickety-clack to doze by when on a train, you will now have to change the routine.

Sheets to the Wind

In the steel and aluminum sheet section at the Chicago, Ill., plant of Joseph T. Ryerson & Son, Inc., a blower for the automatic coil-shearing line now "floats" the cut sheets on a stack at the end of the production line. Previously, sheets were stacked by sliding one on top of another.

Careful Calisthenics

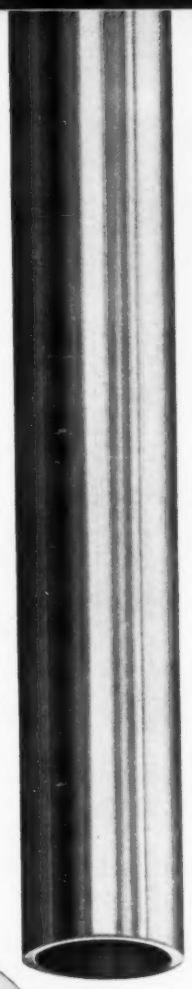
There is a home gymnasium of aluminum on the market which also serves as a rest table. For the people who can't make the couch.



THIS IS ECHO II—a huge aluminum and plastic balloon, which the world should see bobbing through the heavens next year. It is fabricated of Mylar laminated on both sides with ultrathin aluminum foil produced especially for the Echo program by Aluminum Company of America. The balloon, nicknamed "Satelloon," was designed and manufactured by G. T. Schjeldahl Co. for the National Aeronautics and Space Administration. It weighs approximately 500 pounds and is 135 feet in diameter when expanded to full size under the high-pressure injection of helium and air. It will glow brilliantly in the dark, so don't be misled and think other planets are now visiting the earth.

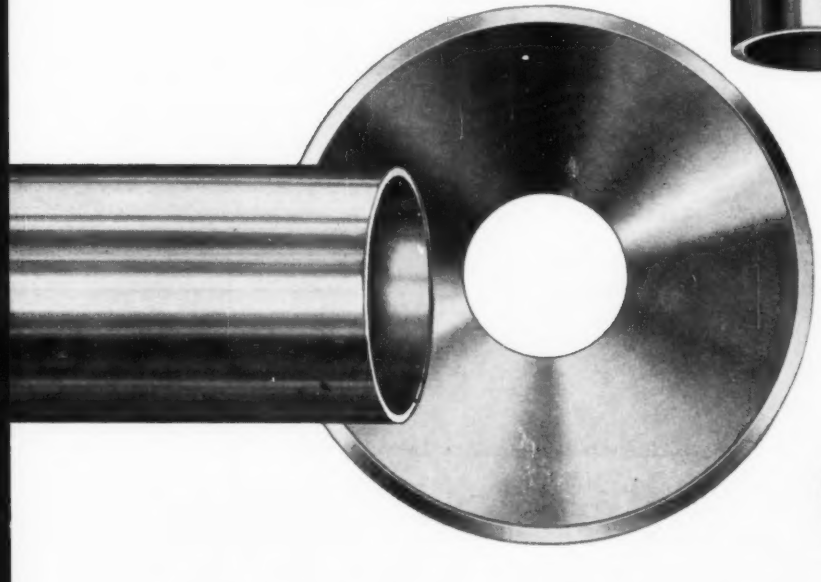
These Remarkable Precision Tubing **Finishes** and **Tolerances** are Economically Produced with the

CINCINNATI® Intraform



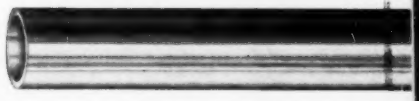
FINISHES
I.D. and O.D. less than 10 micro inches

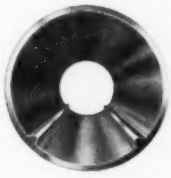
TOLERANCES
O.D. to ± .001"
I.D. to ± .0005"
Ovality to .0002"



MATERIALS

Welded or seamless: Zircaloy Nos. 2 and 3, stainless alloy, and plain or carbon steels. Intraform can also produce laminated tubing of two or more dissimilar metals.





If you make or buy precision tubing, these remarkable tolerances and finishes are important to you! Visit us, write for information, or better still, let us send you a Meta-Dynamics Division Field Engineer to expertly translate Intraform into benefits you can expect from specific application to your operation.

META-DYNAMICS DIVISION

CINCINNATI

THE CINCINNATI MILLING MACHINE CO.
Cincinnati 9, Ohio

Cramer automatic assembling and staking press

Airco arc welder available in 300- and 500-ampere sizes

screw and spline were encased and preloaded in a single cast-aluminum housing which tied the screw and spline together as a unit. Linear loads were taken by the screw, the small diameter of which minimized inertial drag. Lateral and torsional loads were reacted in the spline.

Two of these ball-screw spline actuators were used to provide elevation and azimuth adjustment of a B-58 Hustler Doppler antenna test facility developed by Raytheon. Previously this radar test equipment was checked by actually installing it in a plane and testing it in flight. The ground facility now performs the test in a tunnel only 100 feet long, yet reduces the error from 1 per cent to 1/10 of 1 per cent.

The combination of ball screw and ball spline is particularly adaptable to quality machine tools and fixtures where a high degree of efficiency and accuracy is required and where even the small inertial resistance, present in a heavy screw, is not acceptable.

Circle 592 on Readers' Service Card

Heavy-Duty Assembling and Automatic Staking Presses

Independent pressing and staking forces are adjusted from the lightest tap to 1 ton in a high-speed, fully automatic assembly press now available from the Cramer Controls Corporation, Centerbrook, Conn. Standard interchangeable tooling is adaptable to a wide variety of work, and can be changed by the operator in less than a minute.

Compressed air power and precision machining assure fast, accurate production from primary components, often eliminating subassembling operations as well as design and material limitations. The lower part of the tool fits into the work-bench at the proper working height.

Circle 593 on Readers' Service Card

Heavy-Duty Industrial Arc Welders

A series of heavy-duty industrial arc welders for alternating-current manual and automatic production welding operations has been placed on the market by the Air Reduction Sales Co., a division of Air Reduction Co., Inc., New York City. Designated MCM-AC Bumblebee "S" series, the units come in 300- and 500-ampere sizes and have a 60 per cent duty cycle rating. Employing a transformer with a movable coil design, these welders are said to be among the simplest, most rugged, and least expensive industrial arc welders available. More efficient welding is made possible by eliminating magnetic arc blow and permitting the use of larger electrodes and higher heat values. The simple, mechanically operated, moving coil assures dependable performance, stepless control of welding current, and maximum arc response.

Other advantages are 80-volt open current for instant arc start

and arc stability, easily changed voltage connections, dual 230/460 voltage, and excellent arc characteristics throughout the entire range. Optional features available include a primary switch, voltage reducer, and primary contactor with 115-volt, push-button set control transformer.

Circle 594 on Readers' Service Card

Vickers Products Introduced at Recent Shows

Vickers Incorporated, division of Sperry Rand Corporation, Detroit, Mich., exhibited a complete line of hydraulic power and control equipment for industrial applications at a recent Design Engineering Show.

In-line piston pumps like the one shown in Fig. 1 were among the new products exhibited for the first time. These pumps are designed for a wide range of high-pressure applications requiring low-cost oil hydraulic power. The first units in this series are available in sizes having capacities of 5 and 10 gpm at 1800 rpm, with either fixed or variable displacement. They are rated at 1500 psi, continuous, and 3000 psi, inter-

Fig. 1. Vickers in-line high-pressure piston pump

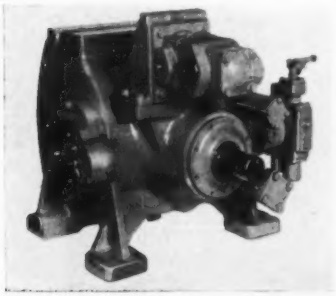


Fig. 2. Variable-delivery heavy-duty piston pump

AUTOMATIC CHUCKING MACHINE

There are no half-finished pieces lying around at the end of the day when you put your work on this outstanding machine.

The "1-2-3" feature—available only on the Goss & De Leeuw Automatic Chucker —provides the means of finsh machining three ends of a part without changing set-up.

Note some of the typical parts machined. Ask for illustrated literature giving further details and samples of your work for a cost estimate on handling it on the Goss & De Leeuw.

GOSS & DeLEEUW QUALITY PRODUCT-QUANTITY

GOSS and DE LEEUW
MACHINE COMPANY, KENSINGTON, CONN., U.S.A.

For more data, circle this page number on Readers' Service Card. 187

mittent. Because of their unusually high over-all efficiency, the pumps operate with minimum temperature rise, and horsepower loss is correspondingly low. Handwheel, servo, and pressure compensator controls are available.

Another product displayed for the first time was a new uprated, variable-delivery piston pump, Fig. 2, for heavy press, cargo winch, and other industrial and marine and ordnance applications requiring high pressure and large volume flow. Pressure rating of this PVA120 angle type pump is 3000 psi, continuous, and 5000 psi, intermittent. This compares to 2000 psi and 3000 psi, respectively, for previous models. Over-all efficiency at 1200 rpm and 5000 psi is approximately 94 per cent. Maximum displacement is 23.71 cubic inches per revolution. Delivery of the unit is 120 gpm at 1200 rpm with atmospheric inlet pressure. Any of four optional control mechanisms can be added along with an auxiliary vane pump which can be mounted on the main pump and driven by it to deliver oil pressure for the pump control actuating system and other auxiliary hydraulic circuits.

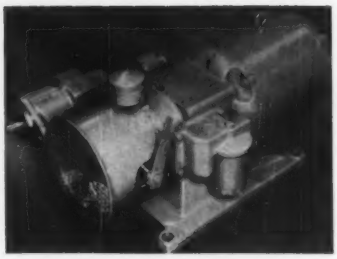


Fig. 3. Vickers variable-speed hydraulic drive

A 4-hp, variable-speed hydraulic drive (Fig. 3) the first in a new series of versatile transmissions designed for a wide range of industrial applications, was also introduced. This unit features unusual installation flexibility. The hydraulic motor can be mounted in three different positions on either side of the hydraulic pump, a total of six positions, and the foot mounting can be rotated 180 degrees. Speed and direction of rotation of the hydraulic motor are controlled by varying the pump displacement with either a handwheel, mechanical lever, or remote electrical control. The no-load maximum speed is 1800 rpm.

Fig. 4. Deceleration valve introduced by Vickers Incorporated

The DG 16S2 deceleration valve, Fig. 4, is a gasket-mounted unit designed to provide an inexpensive means of controlling deceleration of a work-table, machine slide, or other member having linear motion produced by a mechanical cam. It has a rated flow capacity of up to 12 gpm. The compact valve is mounted in a standard directional control valve body. It is especially designed for use on machine tools and similar industrial applications.

Circle 595 on Readers' Service Card

Cam-Operated Rotary Index-Table

A rugged cam-and-roller drive index-table, available in several sizes with a selection of stations, was introduced at the recent ASTME Tool Exposition in New York City by Edward Segal, New York City. The table of the unit can be furnished completely designed and tooled to customers' requirements. It may be set up with an odd number of stations or for double advance. The ratio of dwell time to travel time can be varied by interchangeable cams.

The table features a large non-rotating center which may be tooled to permit mounting auxiliary equipment for operations such as drilling, tapping, staking, clamping, inspection, ejection, and others. Smooth acceleration, travel, and deceleration are provided by the cam and roller design. Extremely heavy work loads may be transported on the table, which is positively synchronized throughout the entire cycle. Backlash is eliminated.

Gear motor drives, variable-speed drives, single-stroke clutch, or hydraulic motor drives are available. An internal switch arrangement actuates external equipment at any desired point in the cycle. A transparent access window in the frame permits observation of cam and pins for timing purposes during setup.

A positive lubrication system is provided for the entire table and individually sealed oil-holes are provided for each cam roller.

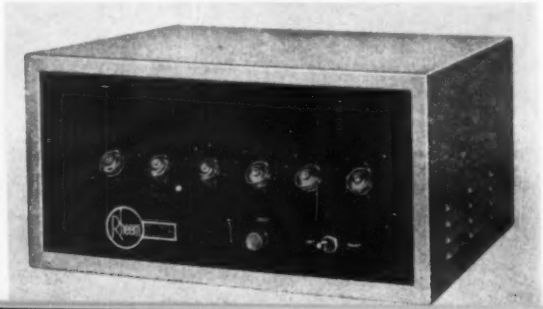
Circle 596 on Readers' Service Card

Rheem "Position Display"

The Rheem "Position Display" introduced by Rheem Electronics, a division of Rheem Mfg. Co., Los Angeles, Calif., has been designed to meet the requirements of operator-controlled machines, including retrofit on existing machines.

Cam-and-roller driven rotary index-table introduced in several sizes by Edward Segal

Position Display unit introduced by Rheem Electronics, a division of Rheem Mfg. Co.



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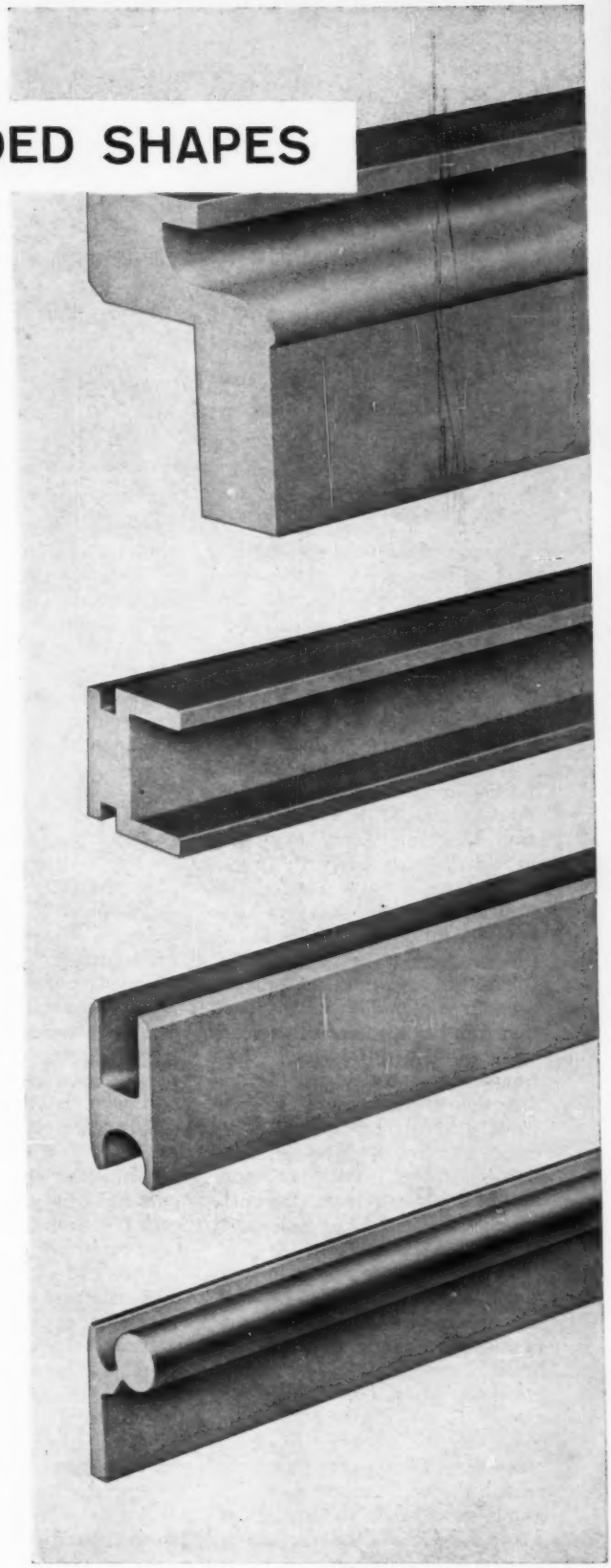
...preferred for superior quality!



Would you like to reduce machining, scrap, and finishing by *cutting* parts from long lengths of extruded shapes?

Anaconda shows you how . . . by designing long lengths of "pre-machined" shapes exactly suited to the parts you need. Parts made from these extruded brass shapes are characterized by their strong, homogeneous, wrought-metal structure. They are superior, long-wearing parts that *improve* the quality of your finished product. What's more, the smooth, extruded surfaces also reduce many finishing operations —additional savings for you.

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EXTRUDED SHAPES

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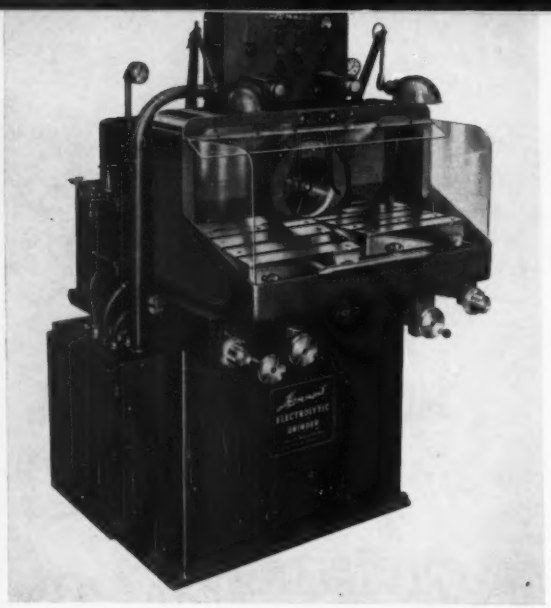
For more data, circle this page number on Readers' Service Card.

Bendix contouring system allows use of off-size cutters



Hammond electrolytic grinder with duplex infeed tables

It allows the operator to position the machine members more rapidly and with greater accuracy, reduce operator fatigue, and avoid errors associated with reading of dials, since dimensional information is clearly displayed. The unit makes it possible for both small and large shops to avail themselves of partial automation where particular machine considerations do not warrant full numerical control. Many of the advantages of automation are now within reach of all shops through maximum utilization of existing machines modified at low cost to use this new equipment.

The Rheem Position Display is used in conjunction with a position transducer geared to a leadscrew or precision rack. The transducer senses magnitude and direction of motion and also provides a signal for indication of machine zero. Position information is displayed on the cathodes of a bidirectional decimal counter which is designed to be mounted adjacent to the operator.

The operator may elect to have displayed the absolute position from a zero reference point continuously, or the incremental distance between two coordinate positions. Normally, the position display is set to count up from machine zero (one end of the machine slide). When direction is reversed, the counter automatically counts down, thus giving the operator a decimal display of absolute machine position at all times.

If the operator elects to use incremental positioning between two coordinate points on the machine slide, the counter must be reset to zero after each operation. This allows the counter to count up from zero and display the incremental dimension or slide movement.

The Rheem Position Display is a compact unit occupying less than 1 cubic foot of space per axis. It is available for one, two, or more axes of motion with typical resolutions of 0.001 or 0.0001 inch and displacements up to 999.999 inches for the 0.001-inch resolution.

Circle 597 on Readers' Service Card

Bendix Numerical-Contouring Controls with Cutter-Size Compensating Feature

The Industrial Controls Section, Bendix Corporation, Detroit, Mich., has announced the availability of cutter compensation as an option on their DynaPath-20 series numerical-contouring controls. This feature makes it possible to machine accurately with cutting tools varying as much as 0.050 inch from the programmed diameter. Thus, reground tools can be used, and both roughing and finishing cuts can be made with the same tool using the same tape control.

The cutter-compensation system generates a secondary signal which is superimposed on the command signals that operate the machine's servo drives. In this way, the required correction is proportioned to each axis, producing a normal offset.

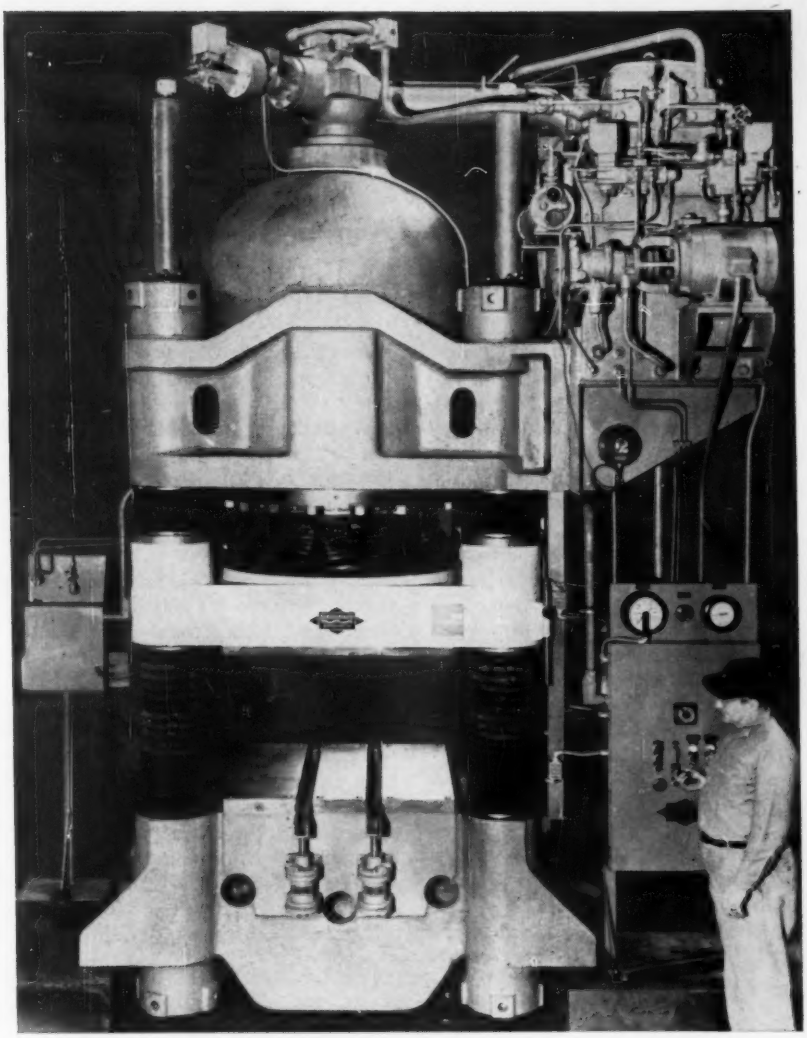
Two controls are mounted on the operator's console with which he indicates the difference between actual and programmed cutter size and the direction in which compensation is to be made. The direction of compensation (normal to the work) is determined by whether the cutter path is to the left or right of the part with respect to tool motion. This setting can also be programmed into the tape, eliminating the need for action by the operator.

Circle 598 on Readers' Service Card

Hammond Oscillating Electrolytic Grinders

Recent additions to the wide line of oscillating electrolytic grinders manufactured by Hammond Machinery Builders, Inc., Kalamazoo, Mich., have been designated Models EGD-12 and 14. These new models have duplex infeed tables, and are especially built for electrolytic grinding of steel and "superalloy" parts as well as carbide tools. Electrolytic grinding with these machines is

2 FOR 1



Both stations of new Birdsboro press operate independently—Result: twice as many grinding wheels in the same time.

There's not a second of idle press time on this Birdsboro hydraulic grinding wheel press. Both stations can operate independently . . . at different approach strokes, tonnages (200 to 1600), and daylight openings.

Unique operating controls assure complete safety. Each operator can lock out the other station, preventing the second operator from activating the press. In an emergency, either operator can stop the press and return it to its open and top position.

Like to gain significant performance advantages like these on your next hydraulic press? Then call in your Birdsboro representative *today*. *Sales Department:* Reading, Pa., *Engineering Department and Mfg. Plant:* Birdsboro, Pa., *District Office:* Pittsburgh, Pa.

HP 48-61

BIRDSBORO

CORPORATION BIRDSBORO, PENNA.

STEEL MILL MACHINERY • HYDRAULIC PRESSES • CRUSHING MACHINERY • SPECIAL MACHINERY • ROLLS • ELECTRIC STEEL CASTINGS: Carbon, Low Alloy and STAINLESS STEEL

said to be burrless, free from metallurgical damage, and to offer outstanding savings in grinding-wheel costs.

The new models accommodate 12- and 14-inch diameter wheels, respectively, and are built for automatic push-button, high-production service.

Circle 599 on Readers' Service Card

Milman "Hydra-Tapper" and Multiple-Spindle Head

The Milman Engineering Co., Inc., Los Angeles, Calif., has brought out a Model T-300 "Hydra-Tapper," Fig. 1, which has several unique features. This machine is capable of controlling and continuously monitoring the torque delivered to the tap. When the tap begins to load up to the preset torque level, the spindle reverses to clear chips and then again reverses automatically to continue the tapping cycle. This feature is particularly useful when tapping materials such as titanium or stainless steel. The machine is lead-screw-driven, but has the unique feature of being able to tap all pitches with the same lead-screw. Pitch changes are simply a matter of changing gears.

The unit is driven by a Vickers hydraulic system which is capable of very high cycling rates without any danger of overheating. Reversing and stopping is accomplished with a simple and reliable solenoid-operated hydraulic valve.

Fig. 1. Hydra-Tapper brought out by Milman Engineering Co., Inc.

A 1-hp, three-phase motor drives the Vickers hydraulic pump through a positive drive coupling. Tap chucks are available for any range of tap sizes up to 3 inches. The standard unit will drive a 1 1/2-inch tap and develop 400-inch-pound stall torque at 1500 psi. On request, torque can be increased to 800 inch-pounds at reduced speeds.

The unit has thirteen spindle speeds between 90 and 611 rpm. Deviation from these spindle speeds can be furnished at no additional cost. The gage mounted on the machine head continuously displays the torque load and can be used for determining when taps are dulling, evaluating cutting fluids, comparing tap styles, and setting torque levels so that the tap and work-piece are continuously protected. The spindle has 4 inches of travel.

The Model T-600 multiple-head, another newly announced product, is shown in Fig. 2 mounted on one of the company's Model T-100 multiple-pitch, automatic lead-screw tapping machines. This head has been designed for applications requiring the drilling or tapping of up to six holes at close center-to-center distances. Although designed primarily as an attachment for the Model T-100 automatic tapper, the unit can be readily adapted to almost any standard drill press. This unit will accommodate up to six spindles, which are adjustable as to position from a minimum center-to-center distance of 0.250 inch to anywhere within a 3-inch diameter circle. The spindles accept individual collets which will hold drills up to 3/32 inch in diameter and taps up to No. 6.

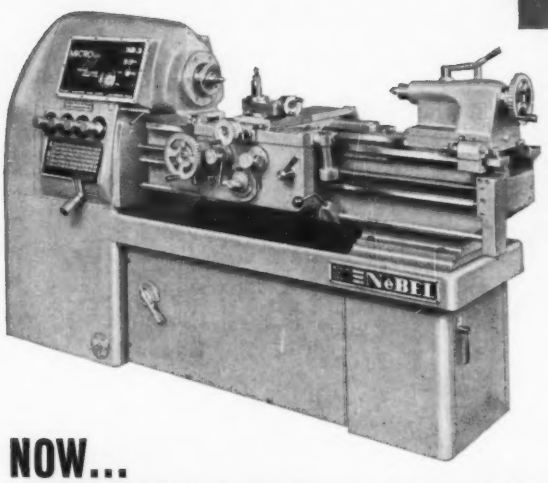
The head has a quill which slides in a housing to provide rigid alignment of the spindle assemblies. The spindle housing fastens directly to the T-100 tapper and can also be adapted to standard drill presses. The main spindle drives a series of hardened and lapped gears within the gearbox. Power to the individually adjustable spindles is transmitted through splined telescoping shafts. Spindles are hardened and ground, and are ball-bearing-mounted to accept thrust loads in both directions. They are quickly adjustable as to position with one turn of an allen wrench.

Fig. 2. Milman Model T-100 automatic tapper equipped with new Model T-600 multiple-spindle head

Circle 600 on Readers' Service Card

Westinghouse Moduline Motocylinders with Guardistor Motors

Moduline motocylinders with Guardistor motor for materials-handling and other applications requiring the transmission of



NOW...
CONTINUOUSLY VARIABLE RANGE OF SPINDLE SPEEDS
WITH CONSTANT HORSEPOWER THROUGHOUT

Now, by simply pressing a button until the desired speed is indicated on the direct-reading tachometer, you can select any spindle speed from 43 to 3500 RPM.
The new Micro-Turn features exclusive Nebel coaxial headstock spindle design plus mechanical beltless type variator drive unit (5 HP), which delivers constant horsepower throughout the entire range and maintains drive output speed within two-tenths of one percent. This assures maximum torque at low speeds for heavy cutting and ultra fine finish at highest speeds, with supreme balance and minimum vibration. Built-in positive torque responsive mechanism prevents slippage under starting or shock loads.

Other features include:

- exclusive feed converter unit, located in apron, providing simple conversion from standard to optional feed ranges without affecting standard thread ranges;
- double-wall, one-piece totally enclosed apron;
- fail-safe pressure lubrication to headstock, gear box and end gearing;
- pressure lubrication to carriage and cross slide ways provided by pump located in apron; one-shot plunger to lubricate cross slide ways when carriage is stationary;
- choice of manual or automatic coolant operation.

For the complete, illustrated story on the revolutionary MICRO-TURN, write today for your copy of Bulletin No. 222. Nebel Machine Tool Corporation, Lathe Division, 3410 Central Parkway, Cincinnati 25, Ohio.

NEBEL
MICRO-TURN
HIGH SPEED PRECISION LATHE

linear motion available from the Westinghouse Electric Corporation, Pittsburgh, Pa. This package equipment is guaranteed for one year against burnouts due to overheating resulting from overload, locked rotor, blocked ventilation, bearing seizure, single phasing, unusual duty cycle, or high ambient or voltage unbalance. The package includes and the guarantee covers the Guardistor motor, whose elements are connected in a "control and warning" system which removes the motor from the power source in the event of overtemperature. Basically, the motocylinder is a gear-motor with a high-torque, high-slip, intermittent rated electric Guardistor motor with an oversize magnetic disc type brake. A crank is mounted on the output shaft and is machined to receive cams which actuate limit switches mounted on the upper part of the gear housing. The cams and limit switches can be adjusted to stop the crankpin at around-the-clock positions. Manual push-button controls or automatic timing controls can be used for starting purposes. The rapid accelebrating and braking action of the motocylinder enables the connected thrust rod to perform a wide variety of functions.

Circle 601 on Readers' Service Card

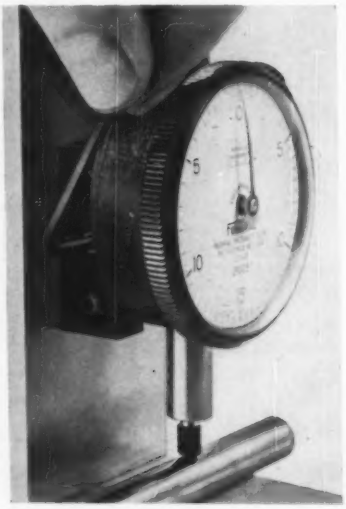
Federal Press Frames of Meehanite Cast Iron

The Federal Press Co., Elkhart, Ind., has adopted Meehanite cast-iron frames for all of the firm's presses. High tensile strength, machine tool grade Meehanite cast iron was selected for its high compressive strength, its vibration dampening qualities, and its ability to withstand deflection from overload without permanent deformation. These qualities and the proper distribution of the metal in the Federal one-piece frames, such as the one shown here, assure maximum rigidity under capacity loading conditions, according to Federal engineers. The Federal line includes open-back inclinable presses in capacities ranging from 7 to 125 tons, dial-feed presses, air clutches, and flying cutoffs.

Circle 602 on Readers' Service Card

Adjustable Mounting Bracket for Federal Dial Indicators

Federal Products Corporation, Providence, R. I., has announced this adjustable bracket for convenient mounting and positioning of Federal dial indicators. The bracket saves time in many indicator setups because the indicator position can be closely and easily adjusted over a range of 7/8 inch and positively locked. A dovetail



is attached to the back of the indicator in place of the regular back to fit the dovetail in the mounting bracket. The indicator is then adjusted by a rack and pinion arrangement and locked by tightening two large clamping screws. Spring washers hold the indicator in alignment during clamping. To mount the entire assembly in place, only two holes need be drilled and tapped. The indicator bracket comes in two models, for AGD Group 1 or 2 Federal indicators, and with the necessary wrench. Dovetail backs are available separately for attachment to spare indicators. An adapter for mounting AirProbes is also available. Special adapters enable mounting of other size indicators and other devices.

Circle 603 on Readers' Service Card

Retracting Contacts for Dial Gages

Dial gage with retractor designed to gage hard-to-get-at dimensions brought out by Standard Gage Co., Inc., Poughkeepsie, N. Y. This device permits AGD accuracy on almost any application which would normally require a less-accurate "long range" model indicator. It can be used on shallow diameter gages to check outside and inside diameters, undercuts, or recesses; on dial snap-gage frames to check external gear or spline pitch diameters; as a modified dial pin gage to check extra deep or narrow inside-diameter grooves; on a comparator base to check wall thickness at the bottom of a deep cup cavity; and on special fixture gages where gage contacts must be retracted to permit fast, easy unloading of the workpiece.

Circle 604 on Readers' Service Card

For strength
. . . economy
. . . versatility

Steel

NO LARGER GENERATOR SHAFT EVER FORGED ANYWHERE

Shipped recently to the General Electric Company's Large Steam Turbine Generator Department at Schenectady, N. Y., this shaft weighs 233,865 lb and measures 38 ft, 9½ in. long. The shaft will be machined and assembled by G. E. for a turbine-generator unit to serve Tennessee Valley Authority's Paradise Steam Generating Station at Paradise, Ky.

The 116-ton shaft was forged from a 120-inch diameter ingot that required the combined output of five electric-furnace heats, or roughly 260 tons of vacuum-poured, nickel-moly-vanadium steel. It was the largest ingot ever cast in a vacuum by Bethlehem. No larger generator shaft has ever been forged.

The generator shaft was fully heat treated and sonic tested. It has a maximum body diameter of 59¼ in.; minimum diameter of the forging is 11¼ in. The generator will operate at 1800 rpm, providing a maximum output of 391,111 kva.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.
Export Sales:
Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

DoALL Special-Purpose Taps

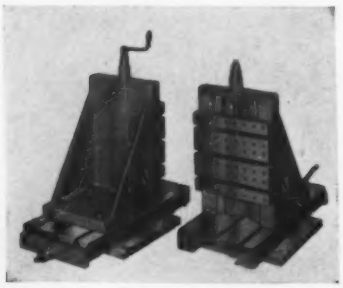
Hy-Hook and neutral-hook taps for applications that require a different cutting action than that obtained with a general-purpose type tap now being carried as regular stock items by the DoALL Co., Des Plaines, Ill. Hy-Hook taps with 10- to 12-degree hook are designed and surface-treated for tapping aluminum, soft-bronze, magnesium, stainless steel, and similar materials that have stringy chip characteristics. Neutral-hook taps with 0- to 3-degree hook are recommended for cast iron, brass, and materials that have brittle type chips. They are also surface-treated for materials of this type. These taps are built with the proper flute spacing and flute contours to meet the requirements of tapping the materials noted. Style selection includes fractional, machine-screw, and taper-pipe tap sizes. All are made of high-speed steel and have ground threads.

Circle 605 on Readers' Service Card

Boring-Machine Fixture

Universal fixture for precision boring machines introduced by Standard Electrical Tool Co., Cincinnati, Ohio. The base mounting holes for both feeds are made concentric to permit selective mounting or assembly. The horizontal feed illustrated with hand feed may also have hydraulic operation. The front and rear views identify features of design, including T-slots, gib screws, manual feed-lock, and micrometer dial with crank handle on each feed. The vertical feed platen has a combination mounting area of T-slots and multiple tapped holes to securely hold either the tool or the work. This universal boring-machine fixture is a combination of two units. The four T-bolts permit instant removal of the vertical angle-plate feed to permit independent use on other machines or for fixturing, bench work, etc. Each slide has a 12-inch width. The angle-plate with 7-inch travel has a 12- by 14 1/2-inch mounting base and 12- by 12-inch T-slotted platen, while the horizontal slide with 12-inch travel has a 16- by 16-inch mounting base and 12- by 28-inch T-slotted platen.

Circle 606 on Readers' Service Card



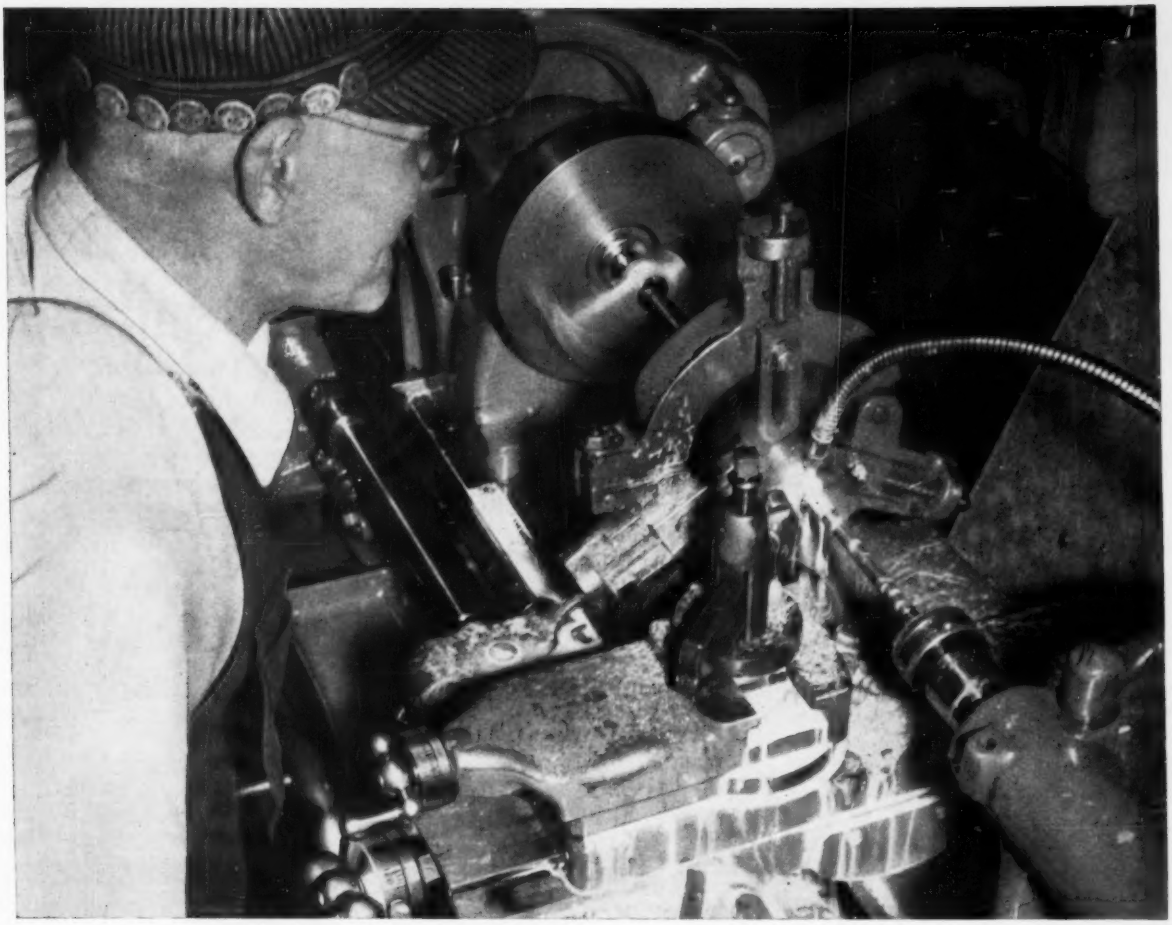
Lincoln Welding Helmets

One of a line of Coolshield welding helmets recently added to the line of welding supplies made by the Lincoln Electric Co., Cleveland, Ohio. Protection, comfort, convenience, and durability are performance features claimed for this new line of welding helmets. Four styles of the fiberglass and polyester-resin molded Coolshield provide a wide range of helmet shapes to accommodate varying physical proportions of welders and different working conditions. Pliable thermoplastic headgear easily adjusts to exact head size and forms itself to exact head shape, thus assuring maximum comfort. A lightproof, durable metal lens holder prevents shock breakage of the lens. A flip type holder is available on one model shield to permit weld inspection and cleaning without moving the entire helmet. Adjusting mechanisms, including headgear stop positions and ratchet size adjustment, are designed for quick positive action. The tough shell will not warp when exposed to heat or moisture. Additional strength to resist breakage and withstand abuse is gained from the reinforcing beading around the shield edges.

Circle 607 on Readers' Service Card

"Micro-Magic" Precision Tooling System for Jig Borers

Guaranteed repetitive accuracy in millionths of an inch that is unimpaired by wear is the salient feature of the "Micro-Magic" tooling equipment announced by the Wadell Equipment Co., Clark, N. J. This tool is intended for use on precision boring machines, jig borers, and any other machine where quick changing of tools for high precision, multiple operations is desirable or necessary. It combines quick changing and positive fine adjustment in one single tool. For example, if one had to rough-bore, finish-bore, and coun-

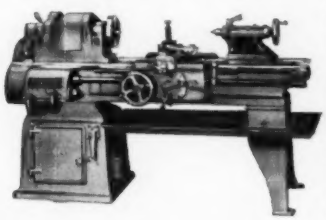


Dependability you can count on / *South Bend 16″ engine lathe*

- Ruggedly designed, accurately built to give long trouble-free service.
- Exceptionally accurate—and they stay accurate.
- Microfinished sleeve type spindle bearings for smoother work, longer life, more accuracy, greater spindle support.
- Hardened and ground bed ways for extreme operating conditions available at small extra cost.
- Trouble-free belt drive to spindle—no noise, no vibration, no gear marks.

16″ LATHE SPECIFICATIONS

Swing over bed and saddle wings — 16¼″. Distances between centers (6 bed lengths) — 33″, 45″, 57″, 81″, 105″ or 129″. Collet capacity — 1 1/16″ max. Spindle speeds — 6, 8, 12 or 16. Threading feeds — 48 (4 to 224 per in.). Longitudinal feeds — 48 (.0015″ to .0841″). Cross feeds — 48 (.0006″ to .0315″).



Prices of South Bend 16″ Engine Lathes start at $2591 f.o.b. factory.

Time payments—3¼% interest per year on unpaid balance, up to 36 months to pay.

SOUTH BEND LATHE

South Bend Lathe, Inc., South Bend 22, Indiana

Please send information on lathes, milling machines, shapers, drill presses and pedestal grinders.

Name_____ Title_____

Company_____

Street_____

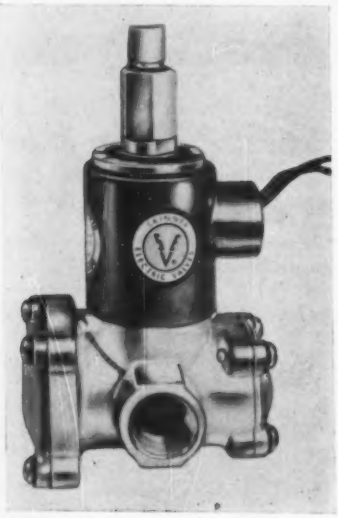
City, Zone, State_____

terbore, the tooling requirements would consist of one complete unit and two extra top plates. After being adjusted, the three top plates can be removed and replaced repetitively to hold work accuracy within a few millionths of an inch of the original settings.

Circle 608 on Readers' Service Card

Three-Way Explosion-Proof Solenoid Valve

Explosion-proof solenoid valve with a 1/2-inch main orifice and 1/2-inch NPTF for use in hazardous locations brought out by Skinner Electric Valve Division, Skinner Precision Industries, Inc., New Britain, Conn. This new high-flow valve is available in normally open, normally closed, and directional control types with operating pressure differentials of 5 to 150 psi. It is UL approved for Class I, Group D, use in atmospheres of gasoline vapors, etc.; for Class II, Group F, coal and coke dust;



and Group G grain dust. A 1/2-inch NPT conduit housing is standard for this valve. The L series have naval forged brass bodies and internal parts of brass and stainless steel, and are available in a wide range of voltages and frequencies.

Circle 609 on Readers' Service Card

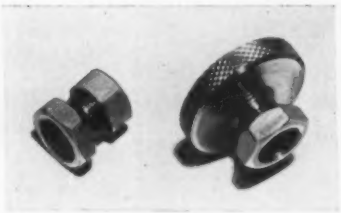
Fixture for Inspecting Optical Instruments

Test fixture designed for efficient inspection of survey type optical instruments—such as theodolites, transits, levels, and jig transits—developed by the Engis Equipment Co., division of Engineering & Scientific Instrumentation, Chicago, Ill. This device combines convenience, efficiency, simplicity in application, and rugged construction. The fixture construction permits rapid calibration of line-of-sight type optical instruments within the limited space of an ordinary inspection laboratory or gage shop. The principle involved is one of autocollimation, using ingeniously arranged mirrors and accessory devices. Thus accuracy checks which ordinarily require extended sighting ranges are performed within arm's length. A manual describing the use of the test fixture—its adjustments, applications and accessory equipment—is now in preparation.

Circle 610 on Readers' Service Card

Knurled Hand Nuts with Shaft-Clamping Feature

An improved series of precision shaft locks for use on potentiometers, capacitators, coils, and other shaft type controls is now available from the Pic Design Corporation, East Rockaway, N. Y. Stocked in two styles, knurled hand nut or wrench hexagonal nut, these collet type locks are available for 1/8- and 1/4-inch shafts in stainless steel or black anodized aluminum. Special sizes are also available.



Circle 611 on Readers' Service Card

Linde Four-In-One Mig Welding Torch

Versatile 500-ampere ST-5 torch for all four types of mig welding—spray-arc, short-arc, plug, and spot welding—announced by Linde Company, division of Union Carbide Corporation, New York City. This versatile torch can be used with all Sigmatic mig welding machines. It features an in-line design, with all service lines (gas, power, water, and wires) entering the torch through the rear of the barrel. With this arrangement these torches can be supported on the welder's shoulder for balanced operation. The ST-5 has a highly efficient cooling system that brings water directly into the nozzle body to cool the contact tube, permitting continuous operation at currents as high as 500 amperes, even with carbon-steel welding wire. The aluminum-alloy pistol-grip handle is adjustable along the torch barrel, and is removable to permit using the torch in a mechanized installation. The large trigger is easily manipulated, even with heavy gloves, and a convenient wire-inching button is located at the base of the handle. Changing from one wire size to another is routine, since contact tubes are changed at the turn of a knob.

Circle 612 on Readers' Service Card

MITSUBISHI
INNOCENTI
CWB

milling boring and combined machine

Universality, productivity and easy handling....

are characteristics of INNOCENTI-CWB milling, boring and combined machine.

MITSUBISHI ZOSEN (Mitsubishi Shipbuilding & Engineering Company) manufacture and distribute the FA 140/95 type (dia. of spindle 140 mm for milling, and 95 mm for boring) of this universally-known machine, licensed by INNOCENTI S.G. of Milano.

Overseas Agents

U.S.A.: Pratt & Whitney, West Hartford • **Canada:** Ryder Machinery Co., Ltd., Toronto • **United Kingdom:** Henderson & Keay, Ltd., Glasgow • **France:** Société d'Etudes de Machines Outils, Outillages et Accessoires, Paris • **Switzerland:** A. Ritschard Machines-Outils SA, Geneve • **Norway:** A/S G. Hartmann, Oslo • **Finland:** OY Machinery AB, Helsinki • **Netherlands:** Technische Import & Export J.L. Bienfait, Asterlaan • **Sweden:** Lundwall & Co., Göteborg • **Denmark:** Scandinavian Phoamix A/S, Copenhagen • **Spain:** Liner Sociedad Anonima, Madrid

MITSUBISHI ZOSEN
(MITSUBISHI SHIPBUILDING & ENGINEERING CO., LTD.)

Head Office: Marunouchi, Tokyo, Japan New York Office: Equitable Bldg., Broadway, New York

Machine tool manufacturing division
HIROSHIMA PRECISION MACHINE WORKS

Sole agent
MITSUBISHI SHOJI KAISHA, LTD.

For more data, circle this page number on Readers' Service Card.

NEWS of the Industry

Isabel Shamlian

California and Washington

The appointment of several distributors to sell and service components under a new marketing plan has been disclosed by LEACH CORPORATION, Compton, Calif. Distribution contracts have been signed with the following: LIBERTY ELECTRIC CORPORATION, Inglewood, Calif.; FLIGHT ELECTRONIC CORPORATION, Inglewood; ATLAS ELECTRONIC CORPORATION, San Diego; and WEATHERBIE INDUSTRIAL ELECTRONICS, INC., San Jose. Others will be announced as negotiations now in progress are completed.

Raymond B. Parkhurst, who has retired as vice-president—manufacturing, Hughes Aircraft Co.

RAYMOND B. PARKHURST has retired as vice-president—manufacturing for HUGHES AIRCRAFT CO., Culver City, Calif. He will continue to serve on a consulting basis. Mr. Parkhurst is credited with introducing mechanized assembly-line techniques to production of military aircraft while with CONSOLIDATED-VULTEE, San Diego, in 1940-1945.

The appointment of JAMES P. BUCKLEY as director of marketing and planning for BENDIX-PACIFIC DIVISION, North Hollywood, Calif., has been announced by BENDIX CORPORATION. Mr. Buckley will be responsible for coordinating the sales programs of the division's varied products.

John A. Manders, vice-president in charge of manufacturing for Burgmaster Corporation

JOHN A. MANDERS has been appointed vice-president in charge of manufacturing by BURGMASTER CORPORATION, Gardena, Calif. He was formerly in charge of tooling, inspection, and methods.

JOHN LASPIA, JR., has been named manager of the Washington office of U. S. INDUSTRIES, INC., New York City. Mr. Laspia joined the company in 1959 as Washington representative.

Illinois

PAUL A. HAYES has been made midwest sales engineer for the Industrial Controls Section of BENDIX CORPORATION, Detroit, Mich. Representing Bendix DynaPath continuous-path and DynaPoint positioning numerical-control systems, he will operate from the company's regional office in Chicago, Ill.

DONALD E. WOODRUFF has been named assistant general manager of sales for JOSEPH T. RYERSON & SON, INC., Chicago, Ill. He joined Ryerson at its Chicago plant in 1939.

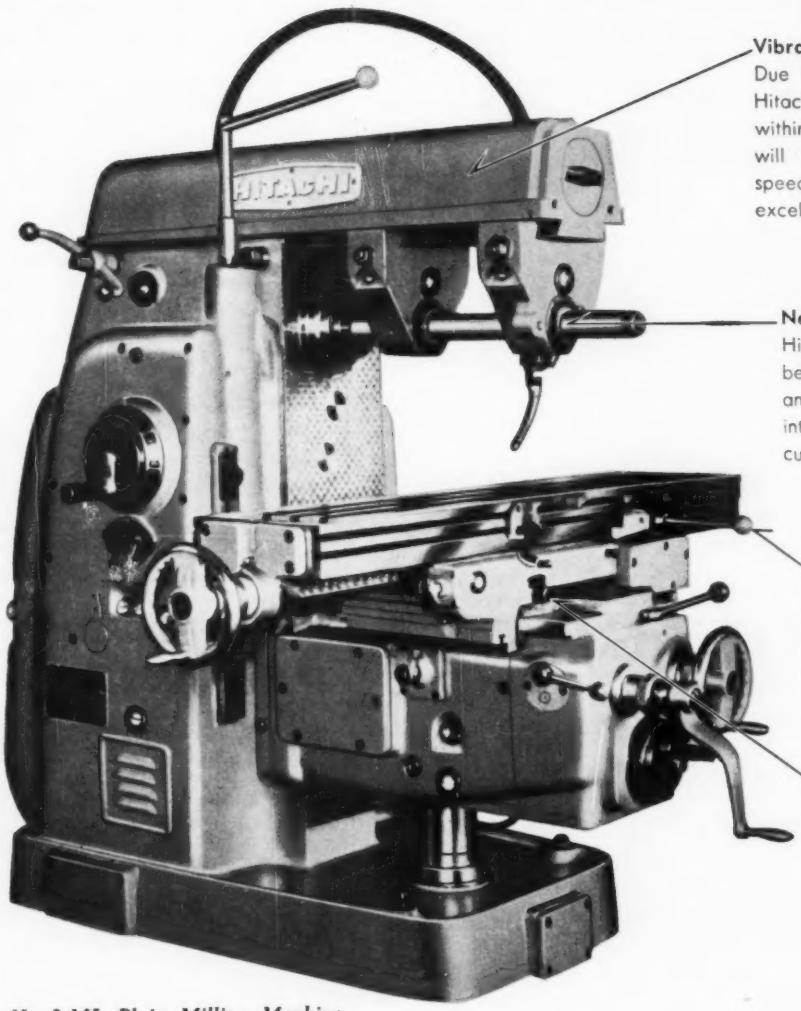
Michigan

DENISON ENGINEERING DIVISION, AMERICAN BRAKE SHOE CO., Columbus, Ohio, has appointed LAWRENCE M. KREBS manager of the Michigan district. In his new assignment, Mr. Krebs will be responsible for the sales of all Denison products in the Michigan area. He will make his headquarters at the company's district office, 900 W. Maple Road, Troy, Mich. JAMES C. JONES has been named a field engineer for Denison, with responsibility for the sale of hydraulic presses and accessories in the eastern half of Michigan. He will also be located at the company's sales office in Troy.

MICHIGAN TOOL CO., Detroit, Mich., has named GEORGE MICKAS manager of the Research and Development Department, coordinating the activities and projects under the direction of the various research engineers, the metallurgical laboratory, and the research and development

George Mickas, manager, Research and Development Department of the Michigan Tool Co.

HITACHI
NO. 2 ML MILLING MACHINES



No. 2 ML Plain Milling Machine

Vibration Damping Device
Due to a vibration damping device of Hitachi's exclusive design contained within the over-arm, minimum vibration will be set up even during higher speeds and feeds operation, so that an excellent finished surface is obtained.

New-Type Arbor Support Bearing
Hitachi's unique super precision-type bearing, a combination of plain metal and needle bearing, is incorporated into the machine to enable high speed cutting with high precision results.

Mono-Lever Control System
Hitachi's unique Mono-lever Control System makes the operation simple and easy. Table-feeding too can be performed with ease.

Backlash Eliminator of Lead Screw
As the use of two independent nuts eliminates backlash on the table feed screw, smooth down-cutting can be effected.

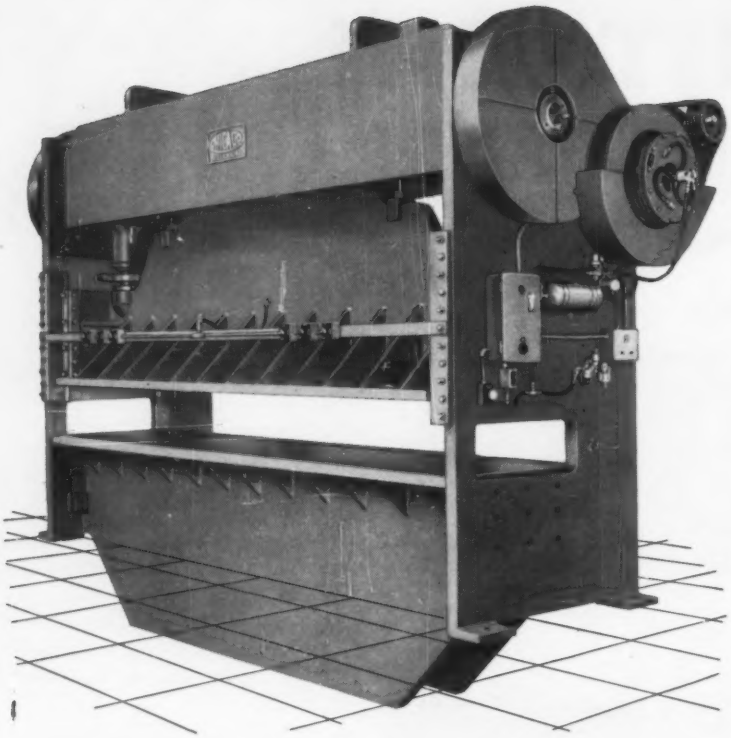
SPECIFICATIONS :

- 53 1/8"×10 1/16" Table
- 28" Longitudinal Traverse
- 16 Table Feeds 1/16" — 78 3/4"/min.
- 16 Spindle Speeds 25 — 1,500 r.p.m.
- 7.5 h.p. Main Motor

Hitachi, Ltd.
Tokyo Japan

Cable Address : "HITACHY" TOKYO

For more data, circle this page number on Readers' Service Card.



CHICAGO DREIS & KRUMP

PRESSES
STRAIGHT-SIDE TYPE

large die area
capacities up to 400 tons

This is a typical model of CHICAGO straight-side-type presses used for multiple punching, notching, and trimming operations. This press with a die area of 48 inches by 198 inches has a capacity of 200 tons.

Complete recommendations for any job on request.

6874

CHICAGO DREIS & KRUMP

Press Brakes • Straight-Side-Type Presses • Press Brake Dies
Hand and Power Bending Brakes • Special Metal-Forming Machines

DREIS & KRUMP
MANUFACTURING CO.
7412 South Loomis Boulevard, Chicago 36, Illinois

shop. Named senior research engineers, directing projects of the department, are W. McCARDELL and W. CARLSEN.

Sale of the METHOD X DIVISION of FIRTH STERLING, INC., Pittsburgh, Pa., to ELOX CORPORATION OF MICHIGAN, Troy, Mich., was announced by officials of the firms. Elox has acquired certain patent rights, licenses, and trademarks, as well as all physical assets of the Method X Division, with the right to acquire all other Method X rights at a future date.

ROBERT W. MATTHEW has been made a sales engineer at FAB-TEC, a subsidiary of F. Jos. LAMB CO., Detroit, Mich. Mr. Matthew joined the Lamb Co. in 1956 as a machine designer, and was a project engineer with Lamb and Fab-Tec until his recent promotion.

New England

THREADWELL TAP & DIE CO., Greenfield, Mass., has announced the appointment of WALTER MAREK as district sales manager, with headquarters in Chicago, Ill. In addition, DONALD WAYNE BARBER has been named sales engineer for the Pennsylvania territory.

ELMER BURT has been appointed assistant sales manager of REED ROLLED THREAD DIE CO., Holden, Mass., subsidiary of UNION TWIST DRILL CO. Mr. Burt was formerly northeast district manager for Union Twist Drill in Athol, Mass.

The appointment of WILLIAM A. MILLARD as branch manager of the Hartford, Conn./Providence, R. I., mill branch warehouse has been announced by CARPENTER STEEL CO., Reading, Pa. Mr. Millard will assist the New England district manager in the direction of sales operations.

RICHARD V. FREEMAN has been made assistant manager of machine tool sales by TAFT-PEIRCE MFG. CO., Woonsocket, R. I. In his new position, Mr. Freeman will be in charge of sales of the company's full line of machine tools and accessories.

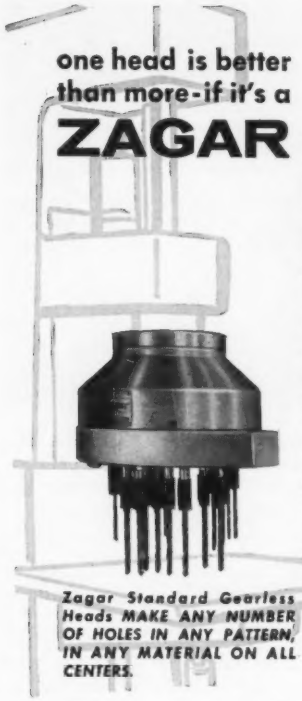
New Jersey and New York

Electronic semiconductor manufacturing operations of BENDIX CORPORATION, New York City, have been established as a separate division of the company to meet increased demand for its product lines. ALBERT J. HARCHER is general

For more data, circle this page number on Readers' Service Card.

one head is better than more-if it's a

ZAGAR Head for Drilling, Reaming and Tapping



1 to 1000 holes in one pass —as close as twice drill diameter. Costs decrease as spindles are added. And, a variety of hole patterns (or parts) can be produced with one fixed center head. Zagar units are adaptable to standard drill presses or are built as a complete installation. Send in your hole problem to Zagar.

Zagar Standard Gearless Heads MAKE ANY NUMBER OF HOLES IN ANY PATTERN, IN ANY MATERIAL ON ALL CENTERS.

Write for Manual "M-8" for engineering data.

Zagar INCORPORATED 23889 LAKELAND BLVD. • CLEVELAND 23, OHIO

USE MORE SPINDLES TO DO MORE WORK

For more data, circle Item 203A on Readers' Service Card

Steel shaft worms and bronze worm gears for open hearth electric hoists are all in the day's work at Stahl. For highly cialized applications, or genera .rpose use—in any size or quantity — of any material — Stahl gears are made right, fit right, last longer. Get our estimate.

SPURS TO 72" PD, 1 DP
BEVELS TO 54" PD, 1 DP
SPIRAL, HELICAL and WORM GEARS TO 48" PD, 2 DP
CONTINUOUS-TOOTH HERRINGBONE TO 60" PD, 2 DP
SPROCKETS TO 72" PD, 2½" CP
RACKS TO 20 FT. LONG, 3 DP
SILENT GEARS; RAWHIDE, BAKELITE, FIBROIL
HEAT-TREATED, CASE OR FLAME HARDENED GEARS— OF CARBON OR ALLOY STEEL

Stahl GEAR & MACHINE COMPANY
3901 Hamilton Ave. Cleveland 14, Ohio

For more data, circle Item 203B on Readers' Service Card

7TH EUROPEAN MACHINE TOOL EXPOSITION

Come to Brussels from September 3 to 12 to the 7th European Machine Tool Exposition. On display will be machine tools and related equipment produced by members of the European Committee for Cooperation of the Machine Tool Industries in Austria, Belgium, Denmark, France, West Germany, Great Britain, Italy, Netherlands, Sweden and Switzerland. In addition, Brussels is a center for many tours; convenient to Paris, Bruges, Antwerp, the Rhine valley and other centers of interest.

A catalog giving all information, including a list of the exhibitors classified by *material produced*, will be published in July and can be ordered now from the General Commissariat. Price, $3 postpaid, registered airmail. Send for a copy now.

Make your hotel reservations now by contacting any WAGONS-LITS // COOK Agency. For information about the Exposition itself write:

GENERAL COMMISSARIAT

7th European Machine Tool Exposition

13, rue des Drapiers Brussels 5, Belgium

Telephone: Brussels 13.25.62 Telegrams: Exmosycomom, Brussels

For more data, circle Item 203C on Readers' Service Card

manager of the newly formed BENDIX SEMICONDUCTOR DIVISION, housed in a new multimillion-dollar facility at Holmdel, N. J. The semiconductor engineering and manufacturing group formerly operated as part of the company's Red Bank division. DR. WALLACE C. CALDWELL, previously plant manager, will be assistant general manager of the new division.

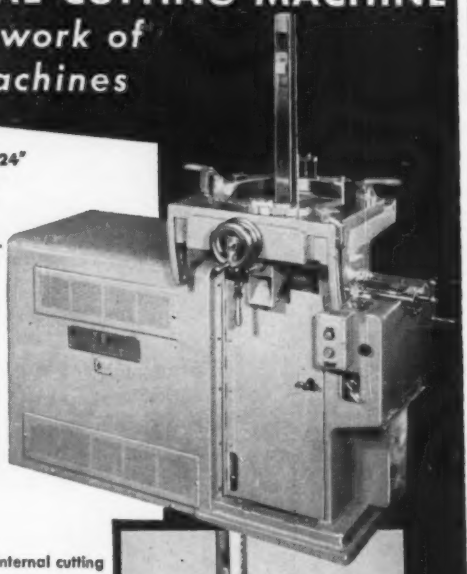
ROBERT F. KOCH, formerly assistant manager, stainless-steel sales, for CARPENTER STEEL CO., Reading, Pa., has been promoted to sales service manager of the firm's WEBB WIRE DIVISION, North Brunswick, N. J. In his new position, Mr. Koch will be responsible for coordinating the Webb and Reading facilities for the sales of fine-wire products. He will make his headquarters at the company's main sales offices in Reading.

PRECISION DRAWN STEEL CO., Pennsauken, N. J., recently completed the largest expansion in its history. The program just completed involved the addition of 62,400 square feet in manufacturing area, and will boost productive capacity by over 20 per cent.

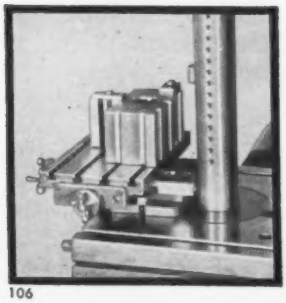
AMAZING NEW HYDRAULIC **M&M** KEYSEATER AND VERTICAL CUTTING MACHINE

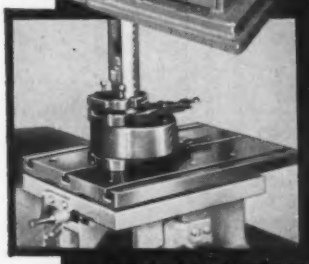
does the work of many machines

In addition to a keyseater that cuts internal keyways up to 3" wide x 24" long, the new hydraulic M & M is a handy tool room machine and can be easily adapted to special production jobs other than keyways. A wide variety of internal or external cuts, serrations, grooves and teeth can be rapidly made on this machine. With a combination tilting table and index table (shown on machine at right) straight or tapered bores and accurately spaced multiple keyways or splines may be cut at any degree of the circle. Send us prints of your cutting problems.



Right: Set-up for internal cutting
Below: Set-up for external cutting





BUILDERS OF MACHINERY SINCE 1854

106

M&M KEYSEATERS AND VERTICAL CUTTING MACHINES

MITTS & MERRILL • 64 Holden St. • SAGINAW, MICHIGAN

William T. Davis, supervisor of manufacturing engineering, Cryogenic Engineering Department of Air Reduction Sales Co.

The appointment of WILLIAM T. DAVIS as supervisor—manufacturing engineering, Cryogenic Engineering Department in Plainfield, N. J., has been announced by AIR REDUCTION SALES CO., a division of AIR REDUCTION CO., INC., New York City. In his new position, Mr. Davis will supervise the fabrication of cryogenic equipment for all Airco's major air separation and cryogenic plants.

John Somerset, appointed a vice-president of Gleason Works

JOHN SOMERSET, sales manager of GLEASON WORKS, Rochester, N. Y., has been named a vice-president of the firm. Mr. Somerset began working at Gleason in production control in 1937. He was appointed assistant sales manager in 1959.

Ohio

RICHARD L. VAN VOORHIS has been named a field engineer for the

DENISON ENGINEERING DIVISION, AMERICAN BRAKE SHOE CO., Columbus, Ohio. In his new post, Mr. Van Voorhis will handle sales engineering projects related to the Denison line of hydraulic pumps and controls in the Ohio area. He will make his headquarters in the company's north-central regional office at 5530 State Road, Cleveland.

T. ALLEN WASHBURN has been appointed district manager, Cleveland, Ohio, by CARPENTER STEEL CO., Reading, Pa. In his new position, Mr. Washburn will be responsible for administration of sales of Carpenter products in the Cleveland, Toledo, and Pittsburgh areas. He will be at Carpenter's mill branch warehouse in Cleveland, located at 4901 W. 150th St.

HYDRAULIC PRESS MFG. CO., Mount Gilead, Ohio, has changed its name to H-P-M DIVISION, KOEHRING CO. There will be no change in sales, administrative, or manufacturing functions. These will continue to be located at the firm's plant in Mount Gilead.

CHARLES G. HERBRUCK has been appointed secretary of the JAMES F. LINCOLN ARC WELDING FOUNDATION, Cleveland, Ohio. Mr. Herbruck has been acting secretary since the death of A. F. DAVIS, the organization's founding secretary.

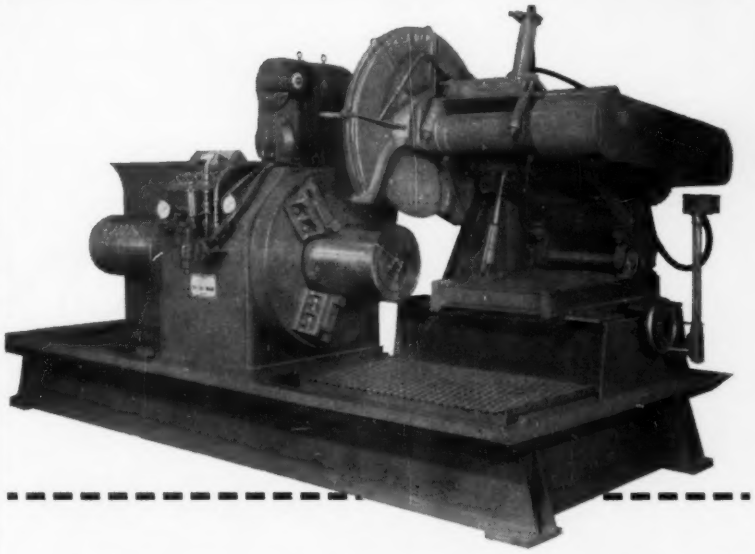
Pennsylvania

CRUCIBLE STEEL COMPANY OF AMERICA, Pittsburgh, Pa., has announced the following: DANIEL A. PORCO and EUGENE A. MARCH have been elected vice-presidents of the firm. Mr. Porco was formerly assistant to the president, and Mr. March, who becomes vice-president of technology, was formerly director of technology. STEPHEN A. FRONEK has been appointed product sales manager of silicon steels. Mr. Fronek joined Crucible in 1925 as a metallurgist at Park Works in Pittsburgh. KENNETH A. MATTICKS has been appointed product manager, stainless flat products. He will be responsible for sales promotion of stainless sheet, strip, and plate for new and existing applications.

Stephen A. Fronek, product sales manager, silicon steels, Crucible Steel Company of America

FIRTH STERLING, INC., Pittsburgh, Pa., has announced the following organizational changes: HARRY J. ALVERSON, JR., is elected treasurer-comptroller, assuming the responsibility for the financial management of the company, in addition to his duties as comptroller. CLYDE N. GILLESPIE is secretary and assistant treasurer, with the corporate functions of secretary of the company plus supervision over credits and collections. DAVID A. TYREE has been named assistant secretary. In this position, he will assist the secretary in corporate duties, in addition to handling all matters of a legal nature as manager of the legal department. G. H. REA has been ap-

Orbit Saw Cuts Rotating Metal—
Single or Double Chucks Up to 22" O.D.



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pointed traffic manager of the firm. He will continue as foreman of central warehouse stocks, in addition to being responsible for coordination of all traffic out of all Firth Sterling shipping locations.

AIR REDUCTION CO., INC., New York City, and SPEER CARBON CO., St. Marys, Pa., have announced that, subject to the approval of each company's board of directors and Speer Carbon's stockholders, agreement has been reached for the acquisition by Air Reduction of Speer Carbon's assets and business in exchange for Air Reduction common stock at the rate of one share of Air Reduction stock for each 2.25 shares of Speer Carbon stock.

The appointment of WILFORD E. METZGER, JR., as assistant sales manager, Hydraulic Machinery Division, Reading, Pa., has been announced by BIRDSBORO CORPORATION, Birdsboro, Pa.

CARPENTER STEEL CO., Reading, Pa., has made WALTER A. BAUMSTARK manager of sales for the Alloy Tube Division, Union, N. J. He was midwestern regional sales manager

Walter A. Baumstark, manager of sales, Alloy Tube Division of the Carpenter Steel Co.

of the division for the past eight years, which position will be filled by HARRY L. HARNER, formerly western regional sales manager. Mr. Harner will make his headquarters in the division's Chicago, Ill., office.

Texas and Florida

REED ROLLER BIT CO., Houston, Tex., has realigned two high-level posts in its CLECO AIR TOOLS DIVISION. R. R. WRIGHT, former chief engineer for Cleco, has been named vice-president of the air tool division, and MARTIN HOZA has been elevated to the post of chief engineer. Mr. Wright joined Reed in 1939. Mr. Hoza, who has been associated with Cleco since 1954, served as head of the division's Research and Development Engineering Department prior to his recent promotion. Also announced was the

R. R. Wright, vice-president of Cleco Air Tools Division, Reed Roller Bit Co.

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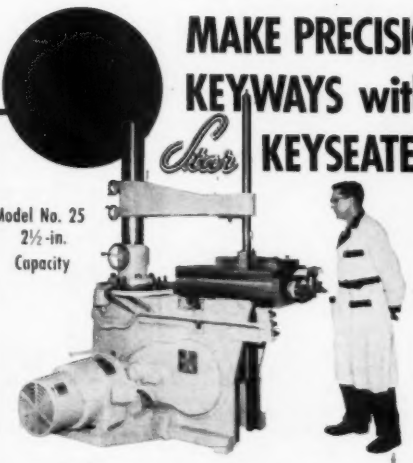

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Martin Hoza, chief engineer for the Cleco Air Tools Division of Reed Roller Bit Co.

appointment of LARRY E. LUTHY as manager of market development. Mr. Luthy was formerly salesman senior.

CHARLES H. HARTON has been made Florida manager for CARPENTER STEEL CO., Reading, Pa. In his new position, Mr. Harton will be responsible for the sale of Carpenter products in the state of Florida.

Australia

ILLINOIS TOOL WORKS, Chicago, Ill., has acquired an ownership interest in W. A. DEUTSHER PTY. LTD., Victoria (near Melbourne), Australia. Deutsher will produce an expanded line of Shakeproof and Fastex fasteners for the automotive, appliance, and electrical industries in Australia—the same major industries serviced by ITW and its several divisions in the United States.

Obituary

Armin G. Kessler

ARMIN G. KESSLER, retired vice-president and director of FARREL-BIRMINGHAM CO., INC., Ansonia, Conn., died suddenly on May 30. Mr. Kessler joined the Farrel organization in 1920 as general manager of the company's plant in Buffalo, N. Y., and was elected vice-president and member of the board of directors in 1923. A well-known figure within industry, he was, for a period, general works manager of all Farrel plants. In 1945 he was appointed manager of sales of the midwestern district, with headquarters at Akron, Ohio. His retirement from the company took place at the end of 1953, and in March of 1955 he also retired as director.

Coming Events

SEPTEMBER 18-20—Standards Engineers Society Tenth Annual Meeting, to be held at the Hotel Sherman, Chicago, Ill. For more information: J. E. Stevens (chairman), Chicago Bridge & Iron Co., 1305 W. 105th St., Chicago 43, Ill.

SEPTEMBER 25-28—National Fall Meeting of the American Welding Society, to be held at the Hotel Adolphus, Dallas, Tex. For further detail, contact Arthur L. Phillips, American Welding Society, 33 W. 39th St., New York 18, N. Y.

SEPTEMBER 28-29—Fourth Annual National Conference and Technical Exhibit of the American Production and Inventory Control Society, to be held at the Pick-Congress Hotel, Chicago, Ill. For more details, contact American Production and Inventory Control Society, 330 S. Wells St., Chicago 6, Ill.

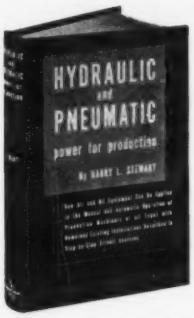
OCTOBER 23-27—1961 Detroit Metal Show and ASM Materials Comparison Center, to be held in Cobo Hall, Detroit, Mich. For additional detail, contact William J. Hilty, exposition manager, American Society for Metals, Metals Park (Novelty), Ohio.

OCTOBER 23-27—Forty-Third National Metal Congress, presented by the American Society for Metals and eight participating organizations, to be held in Cobo Hall, Detroit, Mich. For more information, contact T. C. DuMond, manager, metal congresses, American Society for Metals, Metals Park (Novelty), Ohio.

New Books

HIGH-STRENGTH STEELS FOR THE MISSILE INDUSTRY. Edited by H. T. Sumsion. 276 pages; 8 1/2 by 11 inches; illustrated. Published by the American Society for Metals, Metals Park (Novelty), Ohio. Price, $12.

Problems in development and application of ultrahigh-strength metals for America's missile program are stressed in this technical book for the materials and process engineer. Fourteen authors actively work-



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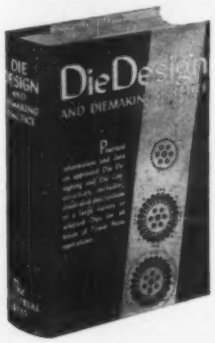

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DIE-CASTING is a valuable reference for everyone in the design, production or use of die-castings. Die-casting machines are illustrated and described. Tables of die-casting alloy compositions are supplemented by text on their properties and applications. 297 pages, 189 illus. $5.00.

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Metal Wear Being Studied

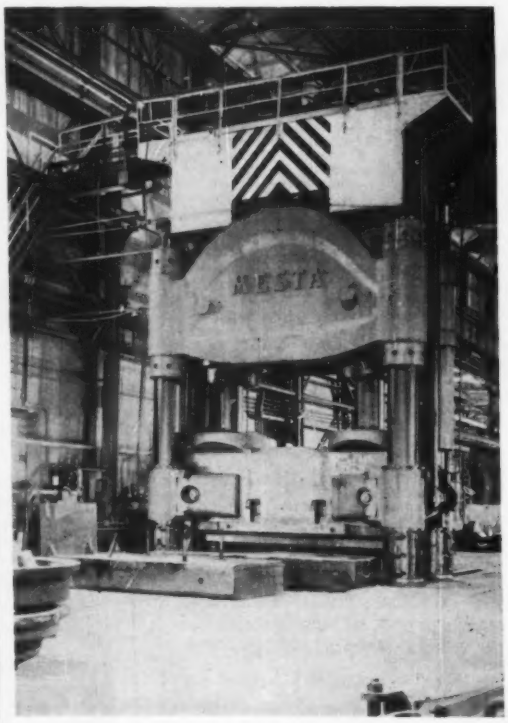
The Wright Aeronautics Division of Curtiss-Wright Corporation has joined a team of nationally known industrial firms in an extensive study to determine the causes of wear and friction in metals, according to the Armour Research Foundation, Illinois Institute of Technology. Initiated a year ago with ten industrial sponsors, ARF researchers on the program are seeking the answers to the age-old mysteries surrounding the wear and friction properties of metals.

The other companies taking part in the three-year, $300,000 program are American Steel Foundries, Bethlehem Steel Co., Briggs & Stratton Corporation, Clevite Corporation, Dow Chemical Co., Inland Steel Co., International Harvester Co., International Nickel Co., Socony-Mobile Oil Co., and U. S. Steel Corp.

"Successful completion of the project will give us a definite direction, for the first time, in the development of a more exact metal wear science," according to Dr. Robert H. Read, Armour Research Foundation's supervisor of physical metallurgy.

"The knowledge realized will aid in the future selection and development of alloys for such products as piston rings, bearings, gears, etc., and will enable industry to save millions annually."

ARF's scientific team—made up of researchers in metals, mechanics, physics, and chemistry—are "forcing" metals to wear by using machines developed to measure metal wear and friction. Equipment being utilized includes X-ray diffraction, electron microscope, microprobe analyzer, radioactive isotopes, and controlled-environment laboratories. By measuring weight loss, changes in dimension, and surface damage, the extent of wear is determined. With the data obtained from the alloys being tested, correlative conclusions are made for the wear and friction properties of other alloys.



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ing with materials for aerospace requirements are represented. The book is comprised of papers presented at the symposium on the same subject during the Golden Gate Metals Conference, February 4-6, 1960, in San Francisco, Calif., sponsored by the Golden Gate Chapter, American Society for Metals.

Contents include: Materials and Fabrication Problems in Pressure Vessels, Stress Corrosion of Aircraft and Missile Steels, Fracture Theory in Pressure Vessels, Pressure Vessel Reliability, NASA's Program—High-Strength Sheet Alloys, New Ultra-High-Strength Steel for High-Performance Rocket Motor Cases, Fabrication Techniques for Rocket Motors, Shear Spinning in Fabrication of Solid-Propellant Rocket Cases, Large Solid-Propellant Rocket Case Fabrication by Deep Drawing, and Future Applications of High-Strength Steels.

THOMAS' REGISTER OF AMERICAN MANUFACTURERS (1961), 51st Edition. 10,000 pages; 9 by 14 inches. Published by Thomas Publishing Co. 461 Eighth Ave., New York 1, N. Y. Price, $20.

The fifty-first edition of this purchasing encyclopedia combines, side by side, the informative advantages of a complete directory to all manufacturers plus 45,000 condensed-catalogue type product descriptions. At the end of each volume is an addendum including data received too late to be classified individually.

The first three volumes alphabetically list products, classified not only by generalized groups but by specific types so that prospective buyers can easily find the particular types to meet their requirements. Under each product classification, the names and addresses of manufacturers are arranged by states and cities, thus facilitating the purchaser's selection of a product within certain geographical boundaries, if desired. In addition, all classifications are thoroughly cross-indexed, and a capital or size rating is given with each product listing.

Volume IV contains an alphabetical list of manufacturers, giving home offices, branches, affiliations, and other information, such as succeeding concerns and cable addresses. Also included is an alphabetical list of trade names, along with an appendix of commercial organizations.

The fifth volume is a product-finding guide to the contents and an index to advertisers.

Individuals concerned with every phase of purchasing for industry—production, engineering, research, etc.—will find this source invaluable.

ENGINEERED CASTINGS. By Glenn J. Cook. 240 pages; 6 by 9 inches; illustrated. Published by McGraw-Hill Book Co., 330 W. 42nd St., New York 36, N. Y. Price, $8.50.

A comprehensive guide for the user and buyer of castings, *Engineered Castings* is a source of broad knowledge for the design engineer as well as a reference book for foundry personnel having duties in marketing, manufacturing, and engineering. The book—in which primary emphasis is given to casting use, rather than casting production—provides the reader with an understanding of metal castings as engineering materials.

Among the topics covered are sand molding, shell molding, investment casting, die castings, inspection and testing, vacuum casting, materials, casting designs and tolerance, and foundry selection.

The book has a number of special features: it covers all modern metals and processes; unique marketing data are presented, representing the combined findings of large and small organizations; the profitable design techniques presented will help the reader save money; and all recent technical advances are described in detail. There are also review questions for each chapter; an extensive bibliography on specialized foundry topics; and many helpful tables of physical properties, tolerances, and specific "do's and don'ts" of casting design.

MAGNETIC CONTROL OF INDUSTRIAL MOTORS—Parts I and II. By Gerhart W. Heumann. 268 and 327 pages, respectively; 6 by 9 inches; illustrated. Published by John Wiley & Sons, Inc., 440 Park Ave. S., New York 16, N. Y. Price, $9 each.

Parts I and II of this three-volume work are devoted to alternating-current motor control problems. Part I deals with the characteristics of alternating-current control devices and their assemblage into complete controllers. Part II covers specific controllers for alternating-current motors and the general problem of protection of motors and their branch circuits.

The first volume opens with a presentation of electrical symbols and discussion of these symbols and diagrams. Chapters 2, 3, 4, and 5

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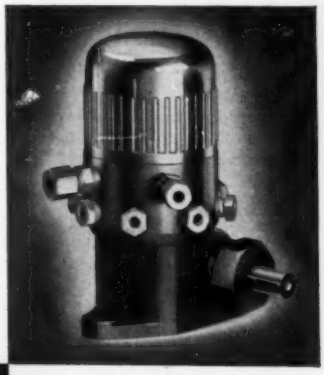

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introduce alternating-current devices and components used as parts of controllers—the building blocks of which controllers are constructed. Chapter 6 deals with solenoids, Thrustor mechanisms, and brakes, which are electrically actuated components performing mechanical work. Chapter 7 is devoted to the mechanical design of controllers, including function and design of enclosures. The eighth, and final, chapter gives general recommendations for the servicing and maintenance of control equipment.

Part II starts out with a discussion of characteristics of mechanical drives powered by electric motors. Chapters 2, 3, and 4 present circuitry and selection of controller components for commonly used industrial alternating-current motors, such as squirrel-cage, wound-rotor, and synchronous motors. Since the control engineer must possess a basic knowledge of motors, particularly speed-torque curves, each chapter starts out with a discussion of the fundamental motor characteristics. Also included in this section are pointers on selection of control devices. Chapter 5 discusses static switching and the concept of logic functions. The sixth and seventh chapters are devoted to the problems of alternating-current motor and branch-circuit protection.

ENGINEERING DATA FOR PRODUCT DESIGN. Edited by Douglas C. Greenwood. 425 pages; 8 1/2 by 11 inches; illustrated. Published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36, N. Y. Price, $10.

The articles in this manual, which are drawn from the *Product Engineering Design Manual*, bring the reader abreast of modern aspects of product design, including dielectric heating, nameplates, metal whiskers, radiation characteristics of metals, high-temperature spring materials, polyamide-cured epoxy, and applications of radioisotopes. It also provides timely information on rubber sandwich material, transducer circuits for control, pressure losses in flexible tubing, and other important areas.

Significant facts and data are conveniently arranged. For example: tables that help in quickly finding the application and characteristics of various metals; information on the application, selection, and properties of plastics, gasket material, glass, enamel, and various other materials; and useful answers to problems in mechanical parts and configurations, ranging from angles and columns to lenses, split rings, and unstable stresses. This quick-reference guide can also be used to brush up on bearing-load analysis, find the data needed on shaft packing, or get the answer to a question on critical speeds. Information on the use and selection of various types of gears, such as worm drives and epicyclic and Geneva gears, is included. In addition, the volume provides information on designing and testing springs, natural frequencies of beams, vibration isolation, and other topics.

ASM REVIEW OF METAL LITERATURE, 1960 (Volume 17). Edited by Marjorie R. Hyslop. 1342 pages; 6 by 9 inches. Published by the American Society for Metals, Metals Park (Novelty), Ohio. Price, $25.

This volume contains 11,903 annotations of articles, technical papers, reports, and documents appearing in engineering, scientific, and industrial journals and books throughout the world during 1960. The book is divided into twenty sections covering different areas of materials and process engineering and technology. It includes addresses of publications as well as comprehensive subject and author indexes.

OPTIMUM DESIGN OF MECHANICAL ELEMENTS. By Ray C. Johnson. 523 pages; 6 by 9 inches; illustrated. Published by John Wiley & Sons, Inc., 440 Park Ave. S., New York 16, N. Y. Price, $11.50.

This book presents a method of mechanical design which is explicit in nature, can be applied to innumerable original design problems, minimizes "cut-and-try" practice, and takes into account the inherently unavoidable limitations confronting practicing mechanical design engineers. The book considers primarily that type of design problem whose solution depends on the employment of some theory. However, it does not preclude such problems for which a satisfactory, if not an optimal, design solution can be obtained without a consideration of theory. In the latter case the application of the method of optimum design can often provide unexpected benefits. The general method, as presented in this book, is the result of the author's many years of industrial and academic experience and, since its formulation, has been applied to the solution of many other original design problems.

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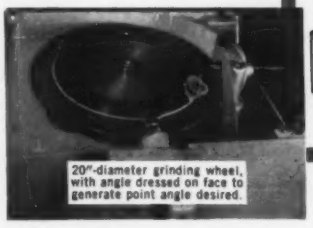
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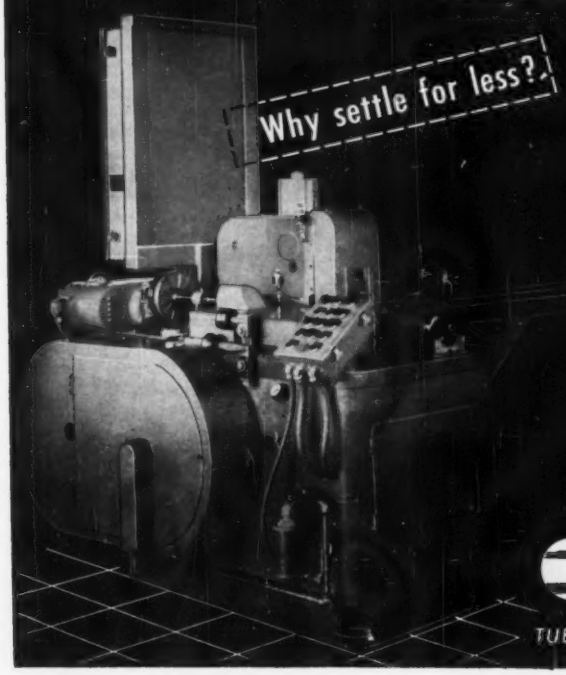

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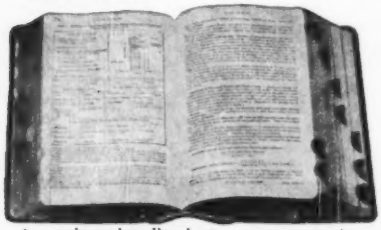

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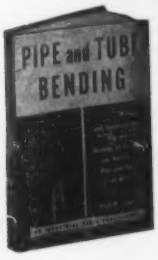

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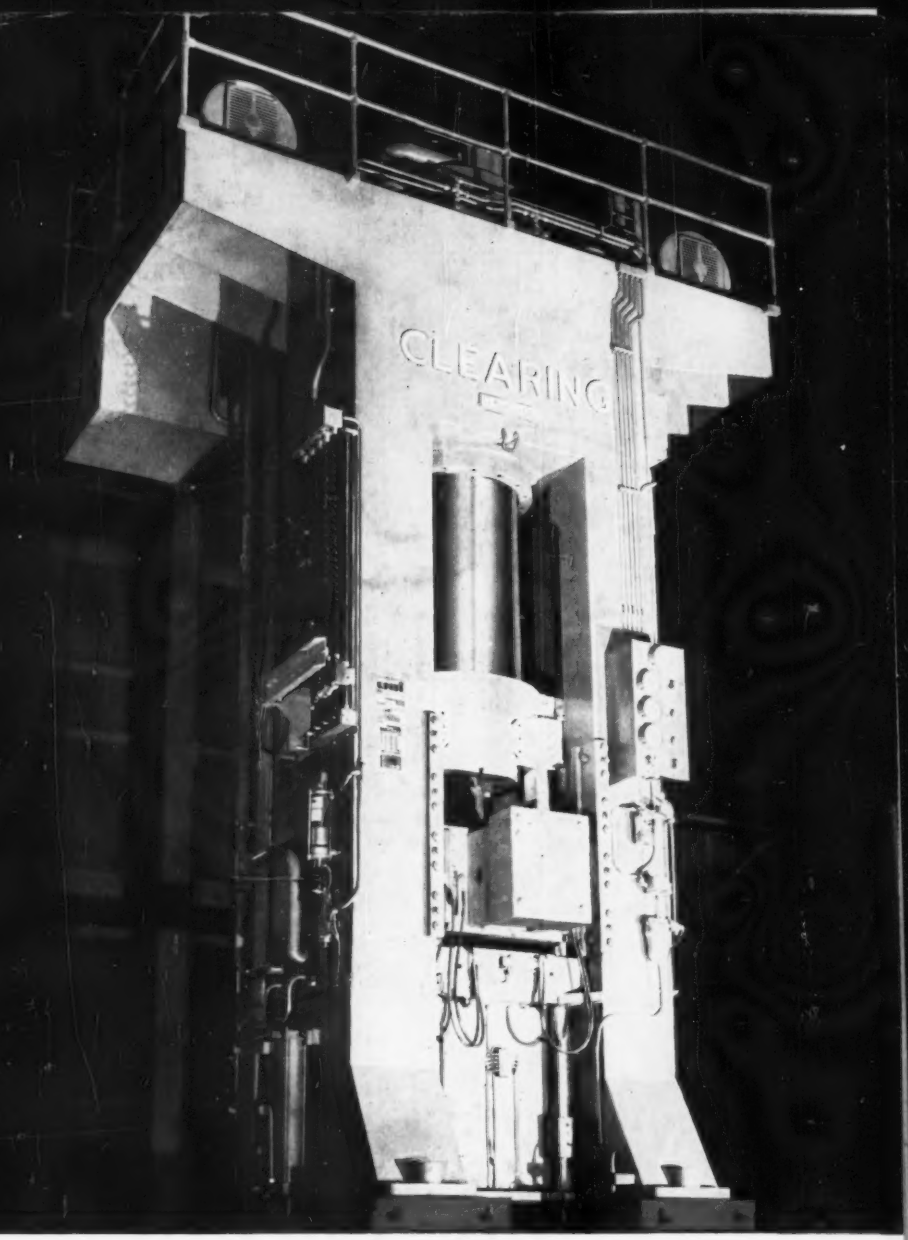

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